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The University of Chicago

FOUNDED BY JOHN D. ROCKEFELLER

PROGRAMME

OF THE

DEPARTMENT OF CHEMISTRY

1895-96

CHICAGO
The University of Chicago Press
1895

CONSPECTUS OF COURSES.

1895-96.

SUMMER	*AUTUMN*	*WINTER*	*SPRING*
2 General Chemistry (*Lengfeld*) MM First Term	1*a* General Chemistry (*Smith*) DM	1*a* General Chemistry (*Smith*) DM	1*b* General Chemistry (*Lengfeld*) DM
5 Qualitative Analysis (*Lengfeld* and *Stieglitz*) DM or DMM	4 Qualitative Analysis (*Stieglitz* and *Bernhard*) DM or DMM	4 Qualitative Analysis (*Stieglitz* and *Bernhard*) DM or DMM	3 General Chemistry (*Smith*) DM
7 Quantitative Analysis (*Lengfeld* and *Stieglitz*) DM or DMM	6 Quantitative Analysis (*Stieglitz*) DM or DMM	6 Quantitative Analysis (*Stieglitz*) DM or DMM	4 Qualitative Analysis (*Stieglitz* and *Bernhard*) DM or DMM
10 Organic Chemistry (*Curtiss*) DMM	8 Elementary Spectrum Analysis (*Stieglitz*) ½ DM	9 Organic Chemistry (*Nef*) DM	6 Quantitative Analysis (*Stieglitz*) DM or DMM
14 Advanced Inorganic Work (*Lengfeld*) M or MM	9 Organic Chemistry (*Nef*) DM	18 Organic Preparations (*Nef*) DM or MM	9 Organic Chemistry (*Nef*) M First Term
19 Organic Preparations (*Curtiss*) DM or DMM	13 Advanced Inorganic Work (*Smith*) DM or DMM	20 Research (All Instructors) DMM	11 Advanced Inorganic Chemistry (*Smith*) ½ DM
20 Research (*Nef* and *Stieglitz*) DMM	18 Organic Preparations (*Nef*) DM or DMM	21 Journal Meeting (*Nef*) ½ DM	13 Advanced Inorganic Work (*Smith*) DM or MM
25 Special Organic Chemistry (*Nef*) ½ M Second Term	20 Research (All Instructors) DMM	24 Organic Nitrogen Derivatives (*Stieglitz*) ½ DM	18 Organic Preparations (*Nef*) M or MM First Term
	21 Journal Meeting (*Nef*) ½ DM	27 Coal Tar Colors (*Ikuta*) ¼ DM	20 Research (All Instructors) DMM
	23 Carbohydrates (*Stieglitz*) ½ DM	28 Gas Analysis (*Stieglitz*) DM	
	27 Coal Tar Colors (*Ikuta*) ¼ DM		

NOTE.—The numbers indicate the numbers of the courses in the detailed description of courses in this programme

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1895/96-1923/24 chemistry)

XX. THE DEPARTMENT OF CHEMISTRY.

OFFICERS OF INSTRUCTION.

JOHN ULRIC NEF, Ph.D., *Professor of Chemistry.*
ALEXANDER SMITH, Ph.D., *Assistant Professor of General Chemistry.*
FELIX LENGFELD, Ph.D., *Assistant Professor of Inorganic Chemistry.*
JULIUS STIEGLITZ, Ph.D., *Instructor in Chemistry.*
MASSUO IKUTA, Ph.D., *Instructor in Chemistry.*
RICHARD S. CURTISS, Ph.D., *Docent in Chemistry.*
ADOLPH BERNHARD, Ph.D., *Laboratory Assistant.*

FELLOWS,

1894-95.

BERNARD C. HESSE, S.B., *Fellow.*
SAMUEL E. SWARTZ, A.B., *Fellow.*
F. B. DAINS, A.B., *Fellow.*
NELLIE E. GOLDTHWAITE, S.B., *Special Fellow.*

INTRODUCTORY.

The lecture and laboratory instruction will be adapted to the wants of beginners as well as the most advanced students. Lectures will be given regularly on General Chemistry, Analytical Chemistry, Theoretical and Physical Chemistry, and advanced Inorganic and Organic Chemistry. Special courses on selected topics will also be given, which will vary from year to year. The chief instruction in every course will, however, be given in the laboratory, as far as the nature of the subject will admit. Only in exceptional cases will students be allowed to hear lectures without taking the corresponding laboratory course. Special stress will be placed on thorough preparation and symmetrical development of the student's knowledge. The object of the courses will be not so much to train specialists as to prepare the student to undertake intelligibly any and every kind of work of a chemical nature. They will, therefore, at present be adapted rather to those looking forward to a career as scientists or teachers, yet it is unquestionable that those intending to become practical chemists will find a thorough course of purely scientific chemistry the best basis for future specialization in any direction whatever. Those who incline towards inorganic chemistry will, therefore, be required to do a considerable amount of organic work, and those proposing to become organic chemists will be required to do work in inorganic chemistry of a more advanced nature than that given in the elementary and analytical courses. (For description of the Kent Chemical Laboratory see Part VII. of this Register).

RESEARCH WORK.

Students offering themselves as candidates for the degree of Doctor of Philosophy must not only observe the general rules of the University in regard to this degree, but must also satisfy the instructors in the different chemical branches that their previous training has been a broad one, and no degree of proficiency in a special branch will be accepted as the equivalent of this. The candidate will at once undertake research, either in Inorganic, Organic, or Physical Chemistry, under the supervision of one of the instructors or docents. The degree will be conferred only after presenting a thesis embodying the results of a satisfactory amount of work which must be a real contribution to knowledge, and after passing an examination on the general field of Chemistry, as well as examinations on one or more secondary, but allied, subjects.

INDEPENDENT WORK.

Special opportunities to pursue entirely independent research work will be given to maturer students who have already obtained the doctor's degree. After completion of a sufficient amount of creditable work, and presentation of a thesis embodying the results obtained, such students may be admitted as *docents*, thereby receiving the right to lecture, give laboratory instruction and supervise research work in the Chemical Department of this University. Students of this class, as well as others, intending to engage in independent research, are requested to make known their special requirements as early as possible, in order that the requisite materials, which are not always accessible in America, may be obtained without delay.

SPECIAL STUDENTS.

Special students, not candidates for a degree, will be received, and will be given every possible facility, but in every case they will be required to give evidence, satisfactory to the instructors in the different branches, that their previous training has been sufficient, both in latitude and amount, to enable them to derive full profit from the courses they propose to take.

SEMINAR WORK.

A chemical Seminar will be held, usually once weekly, in which instructors and all advanced students will take part, and in which recent chemical work will be presented and discussed, and informal lectures given on various topics of interest to chemists.

PREREQUISITES.

A good reading knowledge of French and German is desirable for Courses 3–10, and will be required for Courses 11–27.

Candidates for the degree of Doctor of Philosophy must have taken the first course in General Physics, and they are strongly advised to take the second course in Experimental Physics, which calls for the calculus as a prerequisite. They must also take courses in Crystallography and Mineralogy.

FELLOWSHIPS.

Three fellowships have been assigned to graduate students in chemistry, one yielding an income of $520 annually, two an income of $320 annually. A special fellowship yielding an income of $520 has been given by Mr. L. J. Lamson for 1894–95. The appointments to these fellowships will be based exclusively on merit. A fellow will be expected to render assistance to the Department in serving as an assistant at lectures or in the laboratory. In no case, however, will he be required, or allowed, to devote more than one-sixth of his time to such service.

PUBLICATIONS.

The scientific work carried out in the laboratory will be published in various existing periodicals as "Contributions from the Kent Chemical Laboratory of The University of Chicago." Owing to the fact that a journal devoted to pure scientific work in chemistry already exists in the country, it is deemed unnecessary to edit a departmental journal, but it is likely that the dissertations for a doctor's degree, carried out in the Department, may be published from time to time in the form of "Studies from the Kent Chemical Laboratory."

LIBRARY FACILITIES.

The Department is equipped with an almost complete list of periodicals, past and current, necessary for prosecuting research ; it also possesses a large number of reference and handbooks.

The following periodicals are received by the Department:

> American Chemical Journal; Journal of the Chemical Society (England); Chemical News; Berichte der Deutschen Chemischen Gesellschaft; Liebig's Annalen; Zeitschrift für Analytische Chemie; Zeitschrift für Anorganische Chemie; Zeitschrift für Physikalische Chemie; Journal für Praktische Chemie; Monatshefte für Chemie; Chemiker Zeitung; Chemisches Centralblatt; Jahrbuch der Chemie; Jahresbericht über die Fortschritte der Chemie; Annales de Chimie et de Physique; Bulletin de la Société chimique de Paris; Recueil des Travaux chimiques des Pays-Bas; Gazzetta Chimica Italiana.

A number of general scientific journals and many of the Proceedings of learned societies are received in the General Library.

COURSES OF INSTRUCTION.

Primarily for the Academic College.

1*a*. **General Inorganic Chemistry.** — First Term, Autumn Quarter, lectures 5 hrs a week (no laboratory work). Second Term of Autumn Quarter, and Winter Quarter, lectures 3 hrs a week, laboratory work 6 hrs a week. 2DM.
Assistant Professor Smith.

This course can only be taken continuously from beginning to end.

1*b*. **General Inorganic Chemistry.** — First Term, Spring Quarter, lectures 5 hrs a week (no laboratory work). Second Term, Spring Quarter, lectures 3 hrs a week, laboratory work 6 hrs a week. First Term, Summer Quarter (1896), lectures 6 hrs a week, laboratory work 12 hrs a week. 2DM.
Assistant Professor Lengfeld.

A continuous course extending over three terms (it cannot be taken for a shorter period); the first two terms as a Minor, the third term as a Major. The equivalent of Course 1*a*.

2. **General Inorganic Chemistry.**—First Term, Summer Quarter, 1895, lectures 12 hrs a week (no laboratory work) for two weeks, then lectures 6 hrs a week, laboratory work 12 hrs a week. This is the first half of Course 2; the second half will be given in Summer Quarter, 1896 (first term). It is intended primarily for teachers.
Assistant Professor Lengfeld.

Courses 1 and 2 must be preceded by the college course in General Physics or its equivalent, including some laboratory work.

The aim of Courses 1 and 2 will be to give a definite idea of the fundamental principles of Chemistry, and not to overburden the student with a mass of unconnected facts. The lectures will be experimental to a considerable extent. A knowledge of the characteristic properties of the more common elements and their compounds will be acquired. The course is essential, not only to those who wish to go deeper into Chemistry, but to all who wish to secure a liberal education. Course 1*a* covers two quarters as a Double Minor. Course 1*b* covers one quarter as a Double Minor, one term as a Major. Neither course can be taken for a shorter period. At the option of the instructor an informal examination may be substituted at any time for a lecture or for laboratory work.

Note.—(1) Two hours of laboratory are always reckoned as equal to one hour of lecture work.

(2) Course 2 will not generally be considered the equivalent of Course 1 in the case of students resident at the University during the year.

3. **General Chemistry.**— Chiefly laboratory work in elementary Inorganic Chemistry.
10 hrs a week. DM. Spring Quarter.
Assistant Professor Smith.

Follows Course 1*a* or 1*b*, and prerequisite to Qualitative Analysis (Course 4).

Primarily for the University College.

4. **Qualitative Analysis.**— Chiefly laboratory work. The instructor may at any time substitute one hour of class-room work for two hours of laboratory work.
3DM or 3MM. 10 or 20 hrs a week.
Autumn, Winter, and Spring Quarters.
Dr. Stieglitz and Dr. Bernhard.
Prerequisite: *Courses 1 and 3.*

5. **Qualitative Analysis.**—Laboratory work.
DM or DMM. 10 or 20 hrs a week.
Summer Quarter:
First Term, Dr. Stieglitz and Dr. Bernhard.
Second Term, Assistant Professor Lengfeld and Dr. Bernhard.

The aim in Courses 4 and 5 will be to train the student to do intelligent analytical work and to enable him to analyze, at the end of the course, without the use of a book or table, any mixture containing common inorganic compounds.
Prerequisite: *General Chemistry.*

6. **Quantitative Analysis.**—Chiefly laboratory work in volumetric and gravimetric analysis.
3DM or 3MM. 10 or 20 hrs a week.
Autumn, Winter, and Spring Quarters.
Dr. Stieglitz.
Dr. Bernhard assisting in the Laboratory.
Prerequisite : *Course 4.*

7. **Quantitative Analysis.**—Laboratory work in volumetric and gravimetric analysis.
DM or DMM.
Summer Quarter:
First Term, Dr. Stieglitz.
Second Term, Assistant Professor Lengfeld.
Dr. Bernhard assisting in the Laboratory.

8. **Elementary Spectrum Analysis.**—Emission (flame and electric spark) and absorption spectra of inorganic substances. Chiefly laboratory work.
½ DM. Autumn Quarter.
DR. STIEGLITZ.

FOR THE UNIVERSITY COLLEGE AND GRADUATE SCHOOL.

9. **Organic Chemistry.**—The compounds of carbon, including the fatty and the aromatic series. The aim of the course will be to take up very thoroughly the simpler compounds, going with great detail into the chemical behavior, the characteristic reactions and relationships of the different classes of organic compounds, and considering the synthetic methods by which they can be obtained, with great care. Richter's *Organic Chemistry* is used as a reference book, but recent literature will, in special cases, be considered in detail.
Lectures, 5 M. Autumn and Winter Quarters, and First Term, Spring Quarter.
PROFESSOR NEF.
Prerequisite: *General Chemistry and Qualitative Analysis.*

10. **General Organic Chemistry.**—Fatty and aromatic series.
Lectures, 6 hrs a week; laboratory work, 4 hrs a week, DMM. Summer Quarter.
DR. CURTISS.
Prerequisite: *General Chemistry and Qualitative Analysis.*

11. **Advanced Inorganic Chemistry.**—Two lectures a week on selected topics.
½ DM. Spring Quarter.
ASSISTANT PROFESSOR SMITH.
Prerequisite: *Course 1 or equivalent.*

13. **Advanced Inorganic Preparations.**—Laboratory work.
3M or 3MM. 10 or 20 hrs a week.
Autumn and Spring Quarters.
ASSISTANT PROFESSOR SMITH.
Prerequisite: *Qualitative and Quantitative Analysis, Theoretical Chemistry, Mineralogy, and a reading knowledge of French and German.*

Those intending to pursue research work in Organic Chemistry will be required to take this course as a Triple Minor; those intending to engage in Inorganic Research will be required to take the course as a Triple Major.

14. **Advanced Inorganic Preparations.**
Laboratory work 10 or 20 hrs a week.
M or MM. Second Term, Summer Quarter.
ASSISTANT PROFESSOR LENGFELD.

18. **Organic Preparations.**—Laboratory work.
10 or 20 hrs a week, 3M or 3MM. Autumn and Winter Quarters, and First Term, Spring Quarter.
PROFESSOR NEF.
Prerequisite: *Qualitative and Quantitative Analysis, Mineralogy* (for candidates for the degree of Ph.D.), and *Organic Chemistry* (although it may be taken simultaneously in connection with lectures on Organic Chemistry). Those intending to pursue research work in Inorganic Chemistry will be required to take this course as a Triple Minor, and those intending to pursue research work in Organic Chemistry will be required to take the course as a Triple Major.

19. **Organic Preparations.**—Laboratory work.
10 or 20 hrs a week, DM or DMM. Summer Quarter.
DR. CURTISS.
Prerequisite: *as in Course 18.*

20. **Research Work for Ph.D. Thesis.**—This course will include from 30 to 40 hrs a week of laboratory work, under the special direction of some one of the instructors in the department. It is expected that a student will be occupied for a period of 4–8 quarters, 4–8 DMM.
ORGANIC CHEMISTRY.—Autumn and Winter Quarters; First Term, Spring Quarter; Second Term, Summer Quarter.
PROFESSOR NEF.
GENERAL CHEMISTRY.—Autumn, Winter, and Spring.
ASSISTANT PROFESSOR SMITH.
INORGANIC CHEMISTRY.—Spring.
ASSISTANT PROFESSOR LENGFELD.
ORGANIC CHEMISTRY.—Autumn, Winter, and First Term Spring and Summer Quarters.
DR. STIEGLITZ.

A candidate for the degree of Ph.D. must have taken Courses 1, 3, 4, 6, 9, 13, and 18, as well as at least twelve ½ Double Minors among the special Courses 8, 11, 15, 16, 17, 22, 23, 24, 25, 26, 27, 28, or their equivalent.

Before being admitted to Course 20, a candidate must satisfy the instructors of the department, by an oral test, or otherwise, that his or her previous training has been sufficient.

21. **Journal Meetings.**
Autumn and Winter Quarters.
Professor Nef.

All candidates for the degree of Ph.D., more advanced students, docents and instructors, will be present and take part in turn, in presenting and discussing recent investigations. This course will be held on Fridays from 4:30 to 6 p. m. It may be attended by anyone interested, whether connected with the University or not; the subjects for the meetings will be announced at least one week beforehand.

23. **The Carbohydrates and Complex Hydrocarbons,** (including the terpenes) and their derivatives.
Lectures, 2 hrs a week, ½ DM. Autumn Quarter.
Dr. Stieglitz.
Prerequisite: *Organic Chemistry.*

24. **Organic Nitrogen Derivatives.**—Uric acid series; quinone-imides, pyridine, pyrazol, and phenazine compounds; a discussion of the alkaloids, ptomaines, and organic dye-stuffs.
Lectures, 2 hrs a week, ½ DM. Winter Quarter.
Dr. Stieglitz.
Prerequisite: *Organic Chemistry.*

25. **Special Chapters of Organic Chemistry.**
Lectures, 2 hrs a week, ½M. Second Term. Summer Quarter. Professor Nef.
Prerequisite: *Organic Chemistry.*

27. **The Chemistry of Coal Tar Colors.**
1 hr a week, two ¼ DM. Autumn and Winter Quarters. Dr. Ikuta.

28. **Gas Analysis.**—Laboratory Work. DM. Winter Quarter. Dr. Stieglitz.
Dr. Bernhard assisting in Laboratory.
Prerequisite: *Quantitative Analysis.*

THE KENT CHEMICAL LABORATORY.

OFFICERS OF GOVERNMENT.

JOHN ULRIC NEF, *Professor of Chemistry, and Director.*
ALEXANDER SMITH, *Assistant Professor of General Chemistry.*
FELIX LENGFELD, *Assistant Professor of Inorganic Chemistry.*
JULIUS STIEGLITZ, *Instructor in Chemistry.*
MASSUO IKUTA, *Instructor in Chemistry.*
RICHARD S. CURTISS, *Docent in Chemistry.*
ADOLPH BERNHARD, *Laboratory Assistant.*

THE BUILDING.

The Chemical Laboratory, provided by the benevolence of Mr. Sidney A. Kent, was opened January 1, 1894.*

The rooms are arranged as follows:

The *basement* contains a furnace room, with a set of gas furnaces, with air blast of the most modern construction, for crucible work, muffle work, tube heating, and other purposes, a constant temperature room, a room fitted with steam and other appliances for work on a large scale, a mechanical workshop, and storage rooms.

On the *first floor* are one small and two large lecture rooms, and a large lecture hall seating three hundred persons, fitted for use as a chemical lecture room, if desired. This floor also contains a chemical museum, a large private laboratory, a room with northern exposure, especially fitted for use as a gas analysis laboratory, and also apparatus and preparation rooms connected with the lecture rooms.

On the *second floor* are two large laboratories intended for research and advanced work, three private laboratories for the professors, balance, combustion, air furnace, and store rooms, a balcony for out-of-door work, and the chemical library, which contains full sets of the most important journals, as well as the most important text-books and other works relating to chemistry.

On the *third floor* are three large laboratories for general and analytical chemistry, a store room, a preparation room, a room especially fitted for optical and photographic work, a balance room, and a private laboratory. The most modern system of ventilation has been adopted, air of constant temperature being forced in by fans from below, and withdrawn by a fan above. The building will be lighted throughout by electric lights, and the laboratories will be provided with electricity adapted to every kind of electro-chemical work.

The fullest opportunity will be given for doing research work. All possible aid will be afforded those who desire to avail themselves of the facilities of the laboratory.

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* See THE QUARTERLY CALENDAR No. 8, pp. 20–26.

The Officers of the Department of Chemistry will be glad to answer inquiries from institutions looking for well-equipped teachers of Chemistry.

Letters of inquiry and requests for documents should be addressed to

THE EXAMINER,
THE UNIVERSITY OF CHICAGO,
Chicago, Ill.

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1897/98

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FOUNDED BY JOHN D. ROCKEFELLER

PROGRAMME

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1897-98

CHICAGO
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1897

XX. THE DEPARTMENT OF CHEMISTRY.

OFFICERS OF INSTRUCTION.

JOHN ULRIC NEF, Ph.D., *Head Professor of Chemistry.*
ALEXANDER SMITH, Ph.D., *Assistant Professor of General Chemistry.*
FELIX LENGFELD, Ph.D., *Assistant Professor of Inorganic Chemistry.*
JULIUS STIEGLITZ, Ph.D., *Assistant Professor of Chemistry.*
MASSUO IKUTA, Ph.D., *Instructor in Chemistry.*
RICHARD S. CURTISS, Ph.D., *Docent in Chemistry.*
ADOLPH BERNHARD, Ph.D., *Laboratory Assistant.*
JAMES B. GARNER, Ph.D., *Lecture Assistant.*
LAUDER W. JONES, Ph.D., *Laboratory Assistant*, Summer '97.

FELLOWS.

1896-'97.

LAUDER W. JONES, A.B., *Fellow.*
HERBERT N. McCOY, S.B., S.M., *Fellow.*
FRED NEHER, A.B., A.M., *Fellow.*
JAMES F. SELLERS, A.B., A.M., *Fellow.*
NELLIE E. GOLDTHWAITE, S.B., *Special Fellow.*

1897-'98.

FRED NEHER, A.B., A.M., *Fellow.*
HERBERT N. McCOY, S.B., S.M., *Fellow.*
HENRY C. BIDDLE, A.B., A.M., *Fellow.*

INTRODUCTORY.

The lecture and laboratory instruction will be adapted to the wants of beginners as well as the most advanced students. Lectures will be given regularly on General Chemistry, Analytical Chemistry, Theoretical and Physical Chemistry, and advanced Inorganic and Organic Chemistry. Special courses on selected topics will also be given, which will vary from year to year. The chief instruction in every course will, however, be given in the laboratory, as far as the nature of the subject will admit. Only in exceptional cases will students be allowed to hear lectures without taking the corresponding laboratory course. Special stress will be placed on thorough preparation and symmetrical development of the student's knowledge. The object of the courses will be not so much to train specialists as to prepare the student to undertake intelligibly any and every kind of work of a chemical nature. They will, therefore, at present be adapted rather to those looking forward to a career as scientists or teachers, yet it is unquestionable that those intending to become practical chemists will find a thorough course of purely scientific chemistry the best basis for future specialization in any direction whatever. Those who incline towards inorganic chemistry will, therefore, be required to do a considerable amount of organic work, and those proposing to become organic chemists will be required to do work in inorganic chemistry of a more advanced nature than that given in the elementary and analytical courses. (For description of the Kent Chemical Laboratory see below, page 11 of this Programme).

RESEARCH WORK.

Students offering themselves as candidates for the degree of Doctor of Philosophy must not only observe the general rules of the University in regard to this degree, but must also satisfy the instructors in the different chemical branches that their previous training has been a broad one, and no degree of proficiency in a special branch will be accepted as the equivalent of this. The candidates will at once undertake research, either in Inorganic, Organic, or Physical Chemistry, under the supervision of one of the instructors or docents. The degree will be conferred only after presenting a thesis embodying the results of a satisfactory amount of work which must be a real contribution to knowledge, and after passing an examination on the general field of chemistry, as well as examinations on one or more secondary, but allied, subjects.

INDEPENDENT WORK.

Special opportunities to pursue entirely independent research work will be given to maturer students who have already obtained the doctor's degree. After completion of a sufficient amount of creditable work, and presentation of a thesis embodying the results obtained, such students may be admitted as *docents*, thereby receiving the right to lecture, give laboratory instruction and supervise research work in the Chemical Department of the University. Students of this class, as well as others, intending to engage in independent research, are requested to make known their special requirements as early as possible, in order that the requisite materials, which are not always accessible in America, may be obtained without delay.

SPECIAL STUDENTS.

Special students, not candidates for a degree, will be received, and will be given every possible facility, but in every case they will be required to give evidence, satisfactory to the instructors in the different branches, that their previous training has been sufficient, both in latitude and amount, to enable them to derive full profit from the courses they propose to take.

SEMINAR WORK.

A Chemical Seminar will be held, usually once weekly, in which instructors and all advanced students will take part, and in which recent chemical work will be presented and discussed, and informal lectures given on various topics of interest to chemists.

PREREQUISITES.

A good reading knowledge of French and German is desirable for Courses 9–17, and will be required for Courses 18–42.

Candidates for the degree of Doctor of Philosophy must have taken the first course in General Physics, and they are strongly advised to take the second course in Experimental Physics, which calls for the calculus as a prerequisite. They must also take courses in Crystallography and Mineralogy.

FELLOWSHIPS.

University fellowships yielding an income of $320 or $520 annually are open to graduate students in chemistry. A special fellowship yielding an income of $520 was given by Mr. L. J. Lamson for 1896–7. The appointments to these fellowships will be based exclusively on merit. A fellow will be expected to render assistance to the Department in serving as an assistant at lectures or in the laboratory. In no case, however, will he be required, or allowed, to devote more than one-sixth of his time to such service.

PUBLICATIONS.

The scientific work carried out in the laboratory will be published in various existing periodicals as "Contributions from the Kent Chemical Laberatory of the University of Chicago." Owing to the fact that a journal devoted to pure scientific work in chemistry already exists in the country, it is deemed unnecessary to edit a departmental journal, but it is likely that the dissertations for a doctor's degree, carried out in the Department, may be published from time to time in the form of "Studies from the Kent Chemical Laboratory."

LIBRARY FACILITIES.

The Department is equipped with an almost complete list of periodicals, past and current, necessary for prosecuting research; it also possesses a large number of reference and handbooks.

The following periodicals are received by the Department:

> American Chemical Journal; Journal of the Chemical Society (London); Chemical News; Berichte der Deutschen Chemischen Gesellschaft; Liebig's Annalen; Zeitschrift für Analytische Chemie; Zeitschrift für Anorganische Chemie; Zeitschrift für Physikalische Chemie; Journal of the American Chemical Society; Journal of Physical Chemistry; Journal für Praktische Chemie; Monatshefte für Chemie; Chemiker Zeitung; Chemisches Centralblatt; Jahrbuch der Chemie; Jahresbericht über die Fortschritte der Chemie; Annales de Chimie et de Physique; Bulletin de la Société chimique de Paris; Recueil des Travaux chimiques des Pays-Bas; Gazetta Chimica Italiana.

A number of general scientific journals and many of the proceedings of learned societies are received in the General Library.

COURSES OF INSTRUCTION.

M=Minor course=a single course for six weeks. DM=Double Minor course=a double course (two hours daily) for six weeks.
Mj=Major course=a single course for twelve weeks. DMj=Double Major course=double course for twelve weeks.

PRIMARILY FOR THE JUNIOR COLLEGES.

1, 2, 3. **General Inorganic Chemistry.**—Autumn, Winter and Spring Quarters, class room 3 hrs. a week, 12:00 M.; laboratory 6 hrs. a week 2:00–5:00 P.M. 3Mj.

ASSISTANT PROFESSOR SMITH.

This is a continuous course through three Quarters.

4. **General Inorganic Chemistry.**—Summer Quarter, 1897, lectures 6 hrs. (no laboratory work) for one week, then lectures 4 hrs. a week, 11:00 A.M.; laboratory work 12 hrs. a week, 2:00–5:00 P.M. DMj.

ASSISTANT PROFESSOR LENGFELD.

5. **General Chemistry.**—Chiefly laboratory work.

Mj. Autumn Quarter.

ASSISTANT PROFESSOR SMITH.

Sequel to Course 4 and with it equivalent to Courses 1, 2, 3.

Courses 1 and 4 must be preceded by Preparatory (entrance) Physics or its equivalent, including some laboratory work.

4A, 5A. **General Inorganic Chemistry.**—Autumn and Winter Quarters, class room 3 hrs. a week, 12:00 M.; laboratory 6 hrs. a week, 2:00–5:00 P.M. 2Mj.

ASSISTANT PROFESSOR SMITH.

This course is open only to students having credit for entrance chemistry and physics.

The aim of the equivalent continuous Courses 1, 2, 3; 4, 5; and 4A, 5A will be to give a definite idea of the fundamental principles of chemistry, and not to overburden the student with a mass of unconnected facts. The lectures will be experimental to a considerable extent. A knowledge of the characteristic properties of the more common elements and their compounds will be acquired. The course is essential, not only to those who wish to go deeper into chemistry, but to all who wish to secure a liberal education.

NOTE.—Two hours of laboratory are reckoned as equal to one hour of lecture work.

PRIMARILY FOR THE SENIOR COLLEGES.

6, 7, 8. **Qualitative Analysis.**—Chiefly laboratory work. The instructor may at any time substitute one hour of class-room work for two hours of laboratory work.

2 or 3Mj. or 3DM. 8 or 16 hrs. a week laboratory. 2 hrs. a week class room.

Autumn and Winter Quarters, and First Term of Spring and Summer Quarters.

Lectures: 2:00 P.M.

ASSISTANT PROFESSOR STIEGLITZ.

Second Term, Spring and Summer Quarters.

ASSISTANT PROFESSOR LENGFELD.

DR. BERNHARD or DR. JONES assisting in the Laboratory.

Prerequisite: *Courses 1, 2, 3*, or *4 and 5*, or *4A and 5A*.

Students pursuing chemistry as primary subject will be required to take Courses 6, 7, 8; other students may take 6 and 7.

Courses 6, 7, 8 form a continuous course, which may be begun in any quarter.

The aim in Courses 6, 7, 8 will be to train the student to do intelligent analytical work and to enable him to analyze, at the end of the course, without the use of a book or table, any mixture containing common inorganic compounds.

9, 10, 11. **Quantitative Analysis.** — Chiefly laboratory work in volumetric and gravimetric analysis.

2 or 3Mj, or 3DM. 10 or 20 hrs. a week.

Autumn and Winter Quarters, and First Term of Spring and Summer Quarters.
ASSISTANT PROFESSOR STIEGLITZ.

Second Term, Spring and Summer Quarters.
ASSISTANT PROFESSOR LENGFELD.

DR. BERNHARD or DR. JONES assisting in the Laboratory.

Prerequisite: *Qualitative Analysis.*

Students pursuing chemistry as primary subject will be required to take Courses 9, 10, and 11; others may take 9 and 10.

Courses 9, 10, 11 form a continuous course, which may be begun in any quarter.

PRIMARILY FOR THE GRADUATE SCHOOL.

12. **Elementary Spectrum Analysis (Qualitative).** Emission (flame and electric spark) and absorption spectra of inorganic substances. Chiefly laboratory work.

½ Mj. Winter and Spring Quarters.
DR. BERNHARD.

13. **Special Methods in Quantitative Analysis.**—Special analysis of water, ores, minerals, etc.; gas analysis; analysis by electrolytic methods. 1 to 4 Mj or DM. Chiefly laboratory work.

Autumn and First Term of Spring and Summer Quarters.
ASSISTANT PROFESSOR STIEGLITZ.

Prerequisite: *Courses 9, 10, 11.*

Candidates for the degree of Ph.D. intending to pursue research work in inorganic chemistry will be required to take 2DM or 2Mj of this course; those intending to pursue research work in organic chemistry will be required to take one DM or Mj.

14, 15, 16. **Organic Chemistry.**—The compounds of carbon, including the fatty and the aromatic series. The aim of the course will be to take up very thoroughly the simpler compounds, going with great detail into the chemical behavior, the characteristic reactions and relationships of the different classes of organic compounds, and considering the synthetic methods by which they can be obtained, with great care. Richer's *Organic Chemistry* is used as a reference book, but recent literature will, in special cases, be considered in detail.

Lectures. 5 M. Autumn and Winter Quarters, and First Term of Spring Quarter; 12:00 M.
HEAD PROFESSOR NEF.

Prerequisite: *General Chemistry and Qualitative Analysis.*

17. **General Organic Chemistry.**—Fatty and aromatic series.

Lectures, 5 hrs. a week. Mj.
Summer Quarter; 8:30 A.M.
DR. CURTISS.

Prerequisite: *General Chemistry and Qualitative Analysis.*

18, 19, 20. **Organic Preparations.** — Laboratory work. 10 or 20 hrs. a week, 2 or 3DM, or 2 or 3 Mj.

Autumn and Winter Quarters, and First Term of Spring Quarter.
HEAD PROFESSOR NEF.

Second Term, Spring Quarter.
ASSISTANT PROFESSOR SMITH.

Prerequisite: *Qualitative and Quantitative Analysis, Mineralogy* (for candidates for the degree of Ph.D.), and *Organic Chemistry* (it may be taken simultaneously in connection with lectures on Organic Chemistry). Those intending to pursue research work in Inorganic Chemistry will be required to take 2DM of this course and those intending to pursue research work in Organic Chemistry will be required to take the 3DM. A reading knowledge of French and German is essential.

21, 22. **Organic Preparations.**—Laboratory work. 10 or 20 hrs. a week. 2 Mj or 2 DM. Summer Quarter. DR. CURTISS.

Prerequisite: *as in Course 18.*

23. **Advanced General Chemistry.** — Causes of and conditions for chemical action. 4 hrs. a week.

Mj. Spring Quarter; 8:30 A.M.
ASSISTANT PROFESSOR SMITH.

Prerequisite: *College Physics, General Chemistry and Qualitative Analysis.*

24. **Advanced Inorganic Chemistry.**—Two lectures a week on selected topics. ½Mj.
Autumn Quarter.
ASSISTANT PROFESSOR LENGFELD.

Prerequisite: *General Chemistry and Qualitative Analysis.*

25, 26, 27. **Inorganic Preparations.**—Laboratory work. 2 or 3DM, or 2 or 3 Mj. 10 or 20 hrs. a week.
Summer, Autumn, and Winter Quarters and Second Term of Spring Quarter.
ASSISTANT PROFESSOR LENGFELD.
First Term of Spring Quarter.
ASSISTANT PROFESSOR SMITH.

Prerequisite: *Qualitative and Quantitative Analysis, Theoretical Chemistry, Mineralogy, and a reading knowledge of French and German.*

Those intending to pursue research work in Organic Chemistry will be required to take 2DM of this course; those intending to engage in Inorganic Research will be required to take 3DM.

31, 32. **Theoretical Chemistry.**—With special reference to physical methods. 2 hrs. a week.
½Mj. Autumn and Winter Quarters; 8:30 A.M.
ASSISTANT PROFESSOR LENGFELD.

Prerequisite: *College Physics and General Chemistry.*

33. **Research Work for Ph.D. Thesis.**—This course will include from 30 to 40 hrs. a week of laboratory work, under the special direction of some one of the instructors in the department. It is expected that a student will be occupied for a period of 4–8 quarters, 4–8 DMj.

33*a*. RESEARCH IN ORGANIC CHEMISTRY.—Second Term of Summer Quarter, Autumn and Winter Quarters, and First Term of Spring Quarter.
HEAD PROFESSOR NEF.

33*b*. RESEARCH IN GENERAL CHEMISTRY.
Autumn, Winter, and Spring Quarters.
ASSISTANT PROFESSOR SMITH.

33*c*. RESEARCH IN INORGANIC CHEMISTRY.—All Quarters.
ASSISTANT PROEESSOR LENGFELD.

33*d*. RESEARCH IN ORGANIC CHEMISTRY.—Autumn and Winter Quarters, First Term of Spring and Summer Quarters.
ASSISTANT PROFESSOR STIEGLITZ.

Before being admitted to Research, a candidate must satisfy the instructors of the department, by an oral test, or otherwise, that his or her previous training has been sufficient.

A candidate for the degree of Ph.D. must have taken Courses 1, 2, 3 (or 4, 5), (or 4*A* 5*A*) 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 31, 32; the amount required of courses 18, 19, 20 and 25, 26, 27; as well as at least eight ½Mj among the special Courses 12, 23, 24, 34, 35, 36, 37, 38, 39, 40, 41, 42, or their equivalent.

34. **Physico-Chemical Methods.** — Determination of specific gravity, molecular weights, etc.
Laboratory work 5 hrs. a week.
½Mj. Winter Quarter.
ASSISTANT PROFESSOR LENGFELD.

35. **The Carbohydrates and Complex Hydrocarbons,** (including the terpenes) and their derivatives. Lectures, 4 hrs. a week. M. First Term of Summer Quarter '97 and Autumn Quarter '98.
ASSISTANT PROFESSOR STIEGLITZ.

Prerequisite: *Organic Chemistry.*

36. **Organic Nitrogen Derivatives.**—Uric acid series; pyridine, pyrazol, quinone-imides, and phenazine compounds; a discussion of the alkaloids, ptomaines, and organic dye-stuffs.

Lectures 2 hrs. a week. ½Mj. Winter Quarter '99. ASSISTANT PROFESSOR STIEGLITZ.

Prerequisite: *Organic Chemistry.*

37. **The Chemistry of Methylene.**
Lectures, 4 hrs. a week. M. Second Term.
Summer Quarter; 12:00 M.
HEAD PROFESSOR NEF.

Prerequisite: *Organic Chemistry.*

38. **The Aromatic Series.**—Lectures, 2 hrs. a week.
½Mj. Winter Quarter; 8:30 A.M.
ASSISTANT PROFESSOR STIEGLITZ.

Prerequisite: *Organic Chemistry.*

39. **The Aromatic Series.**—(concluded.)—Lectures, 2 hrs. a week. ½M. First Term, Spring Quarter; 8:30 A.M. ASSISTANT PROFESSOR STIEGLITZ.

40, 41. **The Chemistry of Coal Tar Colors.**
1 hr. a week, two ½ Mj. Autumn and Winter Quarters. DR. IKUTA.

42. **History of Chemistry.** — 2 hrs. a week. Winter and Spring Quarters. Two ½ Mj.
[Not given in '97–8.]

43. **Journal Meetings.**
Autumn and Winter Quarters.
HEAD PROFESSOR NEF.

All candidates for the degree of Ph.D., more advanced students, docents and instructors, will be present and take part in turn, in presenting and discussing recent investigations. Meetings will be held on alternate Fridays from 5:00 to 6:00 P. M. They may be attended by anyone interested, whether connected with the University or not; the subjects for the meetings will be announced at least one week beforehand.

CONSPECTUS OF COURSES.

CHEMISTRY.

SUMMER	*AUTUMN*	*WINTER*	*SPRING*
JUNIOR COLLEGE COURSES			
4 General Chemistry DMj Mon.–Sat. First week 11:00 Then Mon.–Thurs. 11:00 Laboratory: (after one week) Mon.–Thurs. 2:00–5:00 (*Lengfeld*) K 36	1 General Chemistry, continued in Winter and Spring Quarters Mj K 20 Mon.–Wed. 12:00 Laboratory: Thurs. & Fri. 2:00–5:00 (*Smith*) K 36 4A General Chemistry, concluded in Winter Quarter. Mj. Mon.–Wed. 12:00 K 20 Laboratory, Thurs. & Fri. 2:00–5:00 (*Smith*) K 36 5 General Chemistry Mj (*Smith*) K 36 (Sequel to Course 4.)	2 General Chemistry Second Quarter Mj Mon.–Wed. 12:00; K 20 Laboratory: Thurs. & Fri. 2:00–5:00 (*Smith*) K 36 5A General Chemistry, sequel to 4A Mj Mon.–Wed 12:00 K 20 Laboratory: Thurs. & Fri. 2:00–5:00 (*Smith*) K 36	3 General Chemistry Third Quarter Mj Mon.–Wed. 12:00 Thurs. & Fri. 2:00–5:00 (*Smith*) K 36
SENIOR COLLEGE COURSES			
6, 7, 8 Qualitative Analysis M or DM First Term K 24 Lectures: Mon. and Thurs. 2:00 (*Stieglitz*) K 20 6, 7, 8 Qualitative Analysis M or DM Second Term (*Lengfeld*) K 24 9, 10, 11 Quantitative Analysis M or DM First Term (*Stieglitz*) K 24 9, 10, 11 Quantitative Analysis M or DM Second Term K 24 (*Lengfeld*)	6, 7, 8 Qualitative Analysis Mj or DM K 24 Lectures: Mon. and Thurs. 2:00 (*Stieglitz*) K 20 9, 10, 11 Quantitative Analysis Mj or DM (*Stieglitz*) K 24	6, 7, 8 Qualitative Analysis Mj or DM K 24 Lectures: Mon. and Thurs. 2:00 (*Stieglitz*) K 20 9, 10, 11 Quantitative Analysis Mj or DM (*Stieglitz*) K 24	6, 7, 8 Qualitative Analysis M or DM First Term (*Stieglitz*) K 24 6, 7, 8 Qualitative Analysis M or DM Second Term (*Lengfeld*) K 24 9, 10, 11 Quantitative Analysis M or DM First Term (*Stieglitz*) K 24 9, 10, 11 Quantitative Analysis M or DM Second Term (*Lengfeld*) K 24

CONSPECTUS OF COURSES.—continued.

GRADUATE COURSES

SUMMER

13 Special Methods in Quantitative Analysis M or DM First Term (*Stieglitz*) K 24

17 Organic Chemistry Mj Mon.–Fri. 8:30 (*Curtiss*) K 20

21, 22 Organic Preparations Mj or DM (*Curtiss*) K 15

25, 26, 27 Inorganic Preparations Mj or DM (*Lengfeld*) K 15

33*a* Research DM Second Term (*Nef*) K 31

33*c* Research DMj (*Lengfeld*) K 31

33*d* Research DM First Term (*Stieglitz*) K 31

37 Chemistry of Methylene M Second Term Wed–Sat. 12:00 (*Nef*)

35 Carbohydrates M First Term Tues. Wed. Fri. 2:00; Sat. 8:30 (*Stieglitz*) K 20

AUTUMN

13 Special Methods in Quantitative Analysis Mj or DMj (*Stieglitz*) K 24

14 Organic Chemistry Mj Thurs.–Sat. 12:00 (*Nef*) K 20

18, 19, 20 Organic Preparations Mj or DM (*Nef*) K 15

24 Advanced Inorganic Chemistry ½Mj (*Lengfeld*) K 20

25, 26, 27 Inorganic Preparations Mj or DM (*Lengfeld*) K 15

31 Theoretical Chemistry ½Mj Tues. and Fri. 8:30 (*Lengfeld*) K 20

33*a* Research DMj (*Nef*) K 31

33*b* Research DMj (*Smith*) K 31

33*c* Research DMj (*Lengfeld*) K 31

33*d* Research DMj (*Stieglitz*) K 31

40 Coal Tar Colors ½Mj (*Ikuta*) K 20

43 Journal Meeting Fri. 5:00 (*Nef*) K 20

WINTER

12 Elementary Spectrum Analysis ½Mj (*Bernhard*) K 44

15 Organic Chemistry Mj Thurs.–Sat. 12:00 (*Nef*) K 20

18, 19, 20 Organic Preparations Mj or DM (*Nef*) K 15

25, 26, 27 Inorganic Preparations Mj or DM (*Lengfeld*) K 15

32 Theoretical Chemistry ½Mj Tues. and Fri. 8:30 (*Lengfeld*) K 20

33*a* Research DMj (*Nef*) K 31

33*b* Research DMj (*Smith*) K 31

33*c* Research DMj (*Lengfeld*) K 31

33*d* Research DMj (*Stieglitz*) K 31

34 Physico-Chemical Methods ½Mj (*Lengfeld*) K 44

38 Aromatic Series ½Mj Mon. and Thurs. 8:30 (*Stieglitz*) K 20

41 Coal Tar Colors ½Mj (*Ikuta*) K 20

43 Journal Meeting Fri. 5:00 (*Nef*) K 20

SPRING

12 Elementary Spectrum Analysis ½Mj (*Bernhard*) K 44

13 Special Methods in Quantitative Analysis M or DM First Term (*Stieglitz*) K 24

16 Organic Chemistry M First Term Thurs.–Sat. 12:00 (*Nef*)

18, 19, 20 Organic Preparations M or DM First Term (*Nef*) K 15

18, 19, 20 Organic Preparations M or DM Second Term (*Smith*) K 15

23 Advanced General Chemistry Mj Mon.–Thurs. 8:30 (*Smith*)

25, 26, 27 Inorganic Preparations M or DM First Term (*Smith*)

25, 26, 27 Inorganic Preparations M or DM Second Term (*Lengfeld*) K 15

33*a* Research DM First Term (*Nef*) K 31

33*b* Research DMj (*Smith*) K 31

33*c* Research DM Second Term (*Lengfeld*) K 31

33*d* Research DM First Term (*Stieglitz*) K 31

39 Aromatic Series, concluded ½M First Term Fri. and Sat. 8:30 (*Stieglitz*)

THE KENT CHEMICAL LABORATORY.

OFFICERS OF GOVERNMENT.

JOHN ULRIC NEF, *Head Professor of Chemistry and Director.*
ALEXANDER SMITH, *Assistant Professor of General Chemistry.*
FELIX LENGFELD, *Assistant Professor of Inorganic Chemistry.*
JULIUS STIEGLITZ, *Assistant Professor of Chemistry.*
MASSUO IKUTA, *Instructor in Chemistry.*
RICHARD S. CURTISS, *Docent in Chemistry.*
ADOLPH BERNHARD, *Laboratory Assistant.*
JAMES B. GARNER, *Lecture Assistant.*
LAUDER W. JONES, *Laboratory Assistant*, Summer '97.

THE BUILDING.

The Chemical Laboratory, provided by the benevolence of Mr. Sidney A. Kent, was opened January 1, 1894.*

The rooms are arranged as follows:

The *basement* contains a furnace room, with a set of gas furnaces, with air blast of the most modern construction, for crucible work, muffle work, tube heating, and other purposes, a constant temperature room, a room fitted with steam and other appliances for work on a large scale, a mechanical workshop, and storage rooms.

On the *first floor* are one small and two large lecture rooms, and a large lecture hall seating three hundred persons, fitted for use as a chemical lecture room, if desired. This floor also contains a chemical museum, a large private laboratory, a room with northern exposure, especially fitted for use as a gas analysis laboratory, and also apparatus and preparation rooms connected with the lecture rooms.

On the *second floor* are two large laboratories intended for research and advanced work, three private laboratories for the professors, balance, combustion, air furnace, and storerooms, a balcony for out-of-door work, and the chemical library, which contains full sets of the most important journals, as well as the most important text-books and other works relating to chemistry.

On the *third floor* are three large laboratories for general and analytical chemistry, a storeroom, a preparation room, a room especially fitted for optical and photographic work, a balance room, and a private laboratory. The most modern system of ventilation has been adopted, air of constant temperature being forced in by fans from below, and withdrawn by a fan above. The building will be lighted throughout by electric lights, and the laboratories will be provided with electricity adapted to every kind of electro-chemical work.

The fullest opportunity will be given for doing research work. All possible aid will be afforded those who desire to avail themselves of the facilities of the laboratory.

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* See THE QUARTERLY CALENDAR No. 8, pp. 20–26.

The officers of the Department of Chemistry will be glad to answer inquiries from institutions looking for well-equipped teachers in Chemistry.

Letters of inquiry and requests for documents should be addressed to

THE EXAMINER,
THE UNIVERSITY OF CHICAGO,
Chicago, Ill.

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The University of Chicago

FOUNDED BY JOHN D. ROCKEFELLER

PROGRAMME

OF THE DEPARTMENTS OF

MATHEMATICS AND ASTRONOMY

1897-98

CHICAGO
The University of Chicago Press
1897

XVII. THE DEPARTMENT OF MATHEMATICS.

OFFICERS OF INSTRUCTION.

ELIAKIM HASTINGS MOORE, Ph.D., *Head Professor of Mathematics.*
OSKAR BOLZA, Ph.D., *Professor of Mathematics.*
HEINRICH MASCHKE, Ph.D., *Associate Professor of Mathematics.*
WILLIAM HOOVER, Ph.D., *Non-Resident University Extension Assistant Professor of Mathematics.*
JACOB WILLIAM ALBERT YOUNG, Ph.D., *Assistant Professor of Mathematics.*
JAMES HARRINGTON BOYD, Sc.D., *Instructor in Mathematics.*
HARRIS HANCOCK, Ph.D., *Instructor in Mathematics.*
HERBERT ELLSWORTH SLAUGHT, A.M., *Instructor in Mathematics.*

EDGAR ODELL LOVETT, Ph.D., *Lecturer in Mathematics* (Summer Quarter 1897).

FELLOWS AND GRADUATE SCHOLARS.

1896-97.

WILLIAM GILLESPIE, A.B., *Fellow.*
THOMAS EMERY McKINNEY, A.B., *Fellow.*
ARTHUR RANUM, A.B., *Fellow.*
JOHN CHURCHILL HAMMOND, S.M., *Graduate Scholar.*
IDA MAY SCHOTTENFELS, S.M. *Blum Graduate Scholar.*

1897-98.

JOHN CHURCHILL HAMMOND, S.M. *Fellow.*
HENRY LLOYD, S.B., *Fellow.*
JOHN HECTOR McDONALD, A.B., *Fellow.*
IDA MAY SCHOTTERFELS, S.M., *Blum Graduate Scholar*
GILBERT A. BLISS, S.B., *Graduate Scholar.*

INTRODUCTORY.

ENTRANCE REQUIREMENTS.

1. *Algebra*—through radicals, exponents, imaginaries, and theory of quadratic equations. (Special attention should be given to the solution of equations and to miscellaneous problems involving equations.)
2. *Plane Geometry.*
3. *Solid Geometry.*

(The demonstration of original propositions, and the solution of original problems will be required.)

The courses of instruction offered by the Mathematical Department will be considered under the heads; Elementary Mathematics, Introduction to the Higher Mathematics, Modern Mathematics.

ELEMENTARY MATHEMATICS.

The required courses are three consecutive Majors: Course 1, *Plane Trigonometry;* Course 2, *College Algebra,* including the elementary theory of finite and infinite algebraic and trigonometric series; Course 3, *Plane Analytics,* including the analytic geometry of the conic sections. In their first year of residence Junior College students, candidates for the degree of Bachelor of Science are required to take all, and other Junior College students the first two of these courses. The arrangement of sections for the year 1897–8 is given below.

A short course in *Spherical Trigonometry* is regularly offered by the astronomical department.

Course 10, *Culture Calculus* (Major, Summer Quarter), is elective for those students who do not intend to make a special study of Mathematics, and yet are desirous of having at least a glimpse of what lies beyond the elements of the subject.

The Courses 11, 13, 15 *Calculus* I, II, III (three consecutive Majors) may be taken as Junior College Elective. See below.

INTRODUCTION TO THE HIGHER MATHEMATICS.

The following courses introductory to the Higher Mathematics are intended for students making Mathematics their principal subject, and partly also for those making Mathematics their secondary subject, in particular for students of Astronomy and Physics:

(*A*) †*Differential and integral calculus (3Mj).*

(*B*) †*Differential geometry I (1Mj)* ; †*theory of equations, including determinants* (*2Mj*).

(*C*) †*Advanced integral calculus, including definite integrals, Fourier series, elements of elliptic integrals and functions* (*2Mj*); †*differential equations* (*1Mj*).

(*D*) †*Analytic mechanics* (*2Mj*), *theory of the potential, projective geometry, differential geometry II, theory of numbers,* †*elements of the theory of functions of a complex variable.*

The courses marked with a dagger (†) are given annually, the others at least once in two years. Special emphasis will be laid upon the application of calculus to the solution of analytical, geometrical, and mechanical problems. The student who wishes to specialize in Mathematics should take (*A*) as Junior College Elective, (*B*) in his first, (*C*) in his second Senior College year, and (*D*) together with some courses in Astronomy or Mathematical Physics (offered in the respective departments) in his first graduate year. Candidates for the Master's degree with Mathematics as principal subject are expected to cover satisfactorily the topics enumerated under (*A*), (*B*), (*C*), and some of the topics under (*D*).

MODERN MATHEMATICS.

The advanced courses offered in the Graduate School are intended to give the student a comprehensive view of modern Mathematics, to develop him to scientific maturity, and to enable him to follow, without further guidance, the scientific movement of the day, and, if possible, to take an active part in it by original research. To this end general courses on the most important branches of modern Mathematics, such as: theory of functions of a complex variable, elliptic functions, theory of invariants, modern analytical geometry, higher plane curves, algebraic surfaces, theory of substitutions, synthetic geometry, quaternions, are given at least once in two years, while other courses of a more special character and the Seminars are intended to introduce to research work.

THE SUMMER QUARTER.

The courses of the Summer Quarter are designed to meet the needs of college men and others wishing to study advanced Mathematics who are able to spend only the summer in residence. The courses and Seminars of a series of four summer quarters will be arranged so as to give a wide view of modern Mathematics.

The attention of any student wishing the guidance of the department in his continuation of the work done in the summer is called to the correspondence courses of the department given under the auspices of the University Extension division of the University.

MATERIAL FACILITIES OF THE DEPARTMENT.

Library.— The Mathematical library occupies room 37 of the Ryerson Physical Laboratory, adjacent to the lecture-rooms of the department, and is open for the use of graduate students from 8:30 A.M. to 6:00 P.M. The library contains the more important mathematical periodicals, collected works, treatises, and text-books.

Journals.— The following periodicals are on file:

American Journal of Mathematics; American Mathematical Monthly; Annals of Mathematics; Bulletin of the American Mathematical Society.

Mathematical Questions and Solutions from the *Educational Times*; Messenger of Mathematics; Proceedings of the Edinburgh Mathematical Society; Proceedings of the London Mathematical Society; Proceedings of the Royal Society; Quarterly Journal of Pure and Applied Mathematics.

Acta Mathematica; Bibliotheca Mathematica.

Annales de la Faculté des Sciences de Toulouse pour les sciences mathématiques et les sciences physiques; Annales scientifiques de l'École Normale supérieure; Bulletin des Sciences mathématiques; Bulletin de la Société mathématique de France; Intermédiaire des Mathématiciens; Journal de l'École Polytechnique; Journal de Mathématiques pures et appliquées; Journal de Mathématiques élémentaires; Journal de Mathématiques spéciales; Mathesis; Nouvelles Annales de Mathématiques.

Revue semestrielle des Publications mathématiques.

Archiv der Mathematik und Physik; Jahrbuch über die Fortschritte der Mathematik; Jahresbericht der Deutschen Mathematiker-Vereinigung; Journal für die reine und angewandte Mathematik; Mathematische Annalen; Mittheilungen der Mathematischen Gesellschaft in Hamburg; Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften; Zeitschrift für Mathematik und Physik; Zeitschrift für mathematischen und naturwissenschaftlichen Unterricht; Monatshefte für Mathematik und Physik.

Annali di Matematica pura ed applicata; Giornale di Matematiche; Rendiconti del Circolo Matematico di Palermo.

Jornal de Sciencias Mathematicas e Astronomicas.

Models.—A collection of Brill's models: Plaster and thread models of quadric surfaces, plaster models of cubic and Kummer's quartic surfaces, models of cyclides and surfaces of constant positive and negative curvature, thread models of three-dimensional projections of four-dimensional regular bodies.

COURSES OF INSTRUCTION.

1897-98.

M=Minor course=a single course for six weeks. DM=Double Minor course=a double course (two hours daily) for six weeks. Mj=Major course=a single course for twelve weeks. DMj=Double Major course=a double course for twelve weeks.

JUNIOR COLLEGE COURSES.

[NOTE.—Any student permitted to matriculate with entrance conditions in Mathematics is expected to remove these conditions at the next regular entrance examination, and, until this has been done, he may not begin his required college mathematics.]

1. **Plane Trigonometry.** DM.
Second Term. Summer Quarter; 9:30 A.M. and 4:00 P.M. ASSISTANT PROFESSOR YOUNG.

Mj. Autumn Quarter.
Section 1*a*, MR. HAMMOND; 12:00 M.
Section 1*b*, DR. BOYD; 2:00 P.M.
Section 1*c*, DR. BOYD; 9:30 A.M.

Mj. Winter Quarter.
Section 1*a*, MR. SLAUGHT; 12:00 M.
Section 1*b*, DR. HANCOCK; 2:00 P.M.

Mj. Spring Quarter.
DR. HANCOCK; 11:00 A.M.

2. **College Algebra.**—The elementary theory of finite and infinite algebraic and trigonometric series.
Mj. Summer Quarter; 11:00 A.M.
MR. SLAUGHT.

Mj. Winter Quarter.
Section 2*a*, DR. HANCOCK; 12:00 M.
Section 2*b*, DR. BOYD; 2:00 P.M.
Section 2*c*, DR. BOYD; 9:30 A.M.

Mj. Spring Quarter.
Section 2*a*, DR. HANCOCK; 12:00 M.
Section 2*b*, MR. SLAUGHT; 2:00 P.M.

3. **Plane Analytics.**—Elementary analytic geometry of the plane.
Mj. Autumn Quarter; 12:00 M.
DR. HANCOCK.
Mj. Spring Quarter; 12:00 M.
DR. BOYD.

SENIOR COLLEGE COURSES.

[*Junior College Elective.* — The Courses 11, 13, 15: *Calculus* I, II, III, should be taken as Junior College Elective in their second year of residence by those students intending to make a special study of Mathematics, the required Courses 1, 2, 3 having been taken in their first year of residence.]

10. **Culture Calculus.**—Introduction to the Differential and Integral Calculus. This course is planned to illustrate the principles, methods, and applications of the calculus, and its relations to modern mathematics. It is general and summary rather than detailed and exhaustive, and is intended to give to those who do not wish to study Mathematics further an idea of this the most important, characteristic, and indispensable instrument of mathematical thought. A text-book is used largely supplemented by lectures. This course is not sufficient basis for a further study of Mathematics or its applications. Those wishing to specialize in Mathematics, Physics, or Astronomy should elect Courses 11, 13, 15: *Calculus* I, II, III.
Mj. Summer Quarter; 8:30 A.M.
ASSISTANT PROFESSOR YOUNG.

Prerequisite: *Courses 1 and 2.*

11. **Calculus I.** Mj. Autumn Quarter; 8:30 A.M.
DR. BOYD.
Mj. Winter Quarter; 8:30 A.M.
MR. SLAUGHT.

Prerequisite: *Courses 1, 2, 3.*

NOTE.—It is recommended that Course 17 be taken simultaneously with Course 11 or 13.

12. **Integral Calculus.**
Mj. Summer Quarter; 12:00 M.
MR. SLAUGHT.
Prerequisite: *Courses 1, 2, 3, 11.*

13. **Calculus II.** Mj. Winter Quarter; 8:30 A.M.
DR. BOYD.
Mj. Spring Quarter; 12:00 M.
MR. SLAUGHT.
Prerequisite: *Course 11.*

15. **Calculus III.** Mj. Spring Quarter; 8:30 A.M.
DR. BOYD.
Prerequisite: *Course 13.*

[Aside from but in connection with the regular work of his sections Dr. Boyd will hold a *Colloquium:* two-hour sessions fortnightly. Members of the Colloquium will be assigned special problems and subjects to investigate. Students will be admitted after personal interview with the instructor.]

17. **Differential Geometry I.**—*Solid Analytics.* Elements of analytic geometry of three dimensions. Quadric surfaces. Theory of curvature of twisted curves and surfaces.
Mj. Winter Quarter; 9:30 A.M.
ASSOCIATE PROFESSOR MASCHKE.
Prerequisite: *Plane Analytics* and *Differential Calculus.*

NOTE.—Course 17 may be taken simultaneously with Courses 11 or 13.

18. **Determinants.**—The elementary theory of determinants, together with some of their most important applications, will be given.
M. First Term. Summer Quarter; 9:30 A.M.
ASSISTANT PROFESSOR YOUNG.
Prerequisite: *College Algebra.*

19, 21. **Theory of Equations I, II.**—Burnside and Panton's *Theory of Equations* is used as the basis of the work, being supplemented by lectures by the instructor and by reports by the students on topics for reading not treated in the text. Chapters I–XIV of the text are taken up.
2Mj. Autumn and Winter Quarters; 11:00 A.M.
DR. HANCOCK.
Prerequisite: *Plane Analytics* and *Differential Calculus.*

NOTE.—Courses 11 and 19 may be taken simultaneously.

20. **Theory of Equations.**—Based on Burnside and Panton's *Theory of Equations.*
Mj. Summer Quarter.
Prerequisite: *Analytic Geometry* and *Differential Calculus.*
[Not to be given in 1897.]

23, 25. **Advanced Integral Calculus I, II.**—Including definite integrals, Fourier's series, and the elements of elliptic integrals and functions.
2Mj. Autumn and Winter Quarters; 12:00 M.
PROFESSOR BOLZA.
Prerequisite: *Calculus* and *Theory of Equations.*

24. **Advanced Integral Calculus.**—Theory of definite integrals. Mj. Summer Quarter; 9:30 A.M.
PROFESSOR BOLZA.
Prerequisite: *Calculus.*

27. **Differential Equations.**—This course is a continuation of Course 25. Ordinary differential equations and elements of the theory of partial differential equations, with especial attention to certain important differential equations occurring in Astronomy and Physics.
Prerequisite: *Advanced Integral Calculus.*
[Not to be given in '97–8.]

GRADUATE COURSES.

30. **Conferences on Mathematical Pedagogy.**—Selected topics from the teaching of preparatory and collegiate mathematics will be considered.
M. First Term, Summer Quarter; 4:00 P.M.
ASSISTANT PROFESSOR YOUNG.

35. **Mathematical Reading.**—When it is advisable that students undertake definite mathematical reading not closely connected with any current lecture course, such reading will be directed by one or other of
PROFESSORS MOORE, BOLZA, MASCHKE.

[ASTRONOMY 21.] **Analytical Mechanics I.—Statics** (*Part 1*).—Composition and equilibrium of forces applied at a point. The center of gravity of lines, surfaces, and volumes. Attraction of bodies upon a point. **Kinematics.**—Acceleration, the rectilinear and the curvilinear motion of a material point and the forces that produce them. To be followed by 22.
Mj. Autumn Quarter; 8:30 A.M.
MR. MOULTON.

[ASTRONOMY 22.] **Analytical Mechanics II.—Statics** (*Part 2*).—Composition and equilibrium of forces applied to an invariable system; principle of virtual velocities. **Dynamics.**—Principle of d'Alembert, moments of inertia; rotation of a body around an axis; general motion of a system of bodies. Rotation of a body around a point. To be preceded by 21.
Mj. Winter Quarter; 8:30 A.M.
DR. LAVES.

Prerequisite: *Differential and Integral Calculus* and *Differential Equations.**

*The first quarter's work in Analytical Mechanics will be open to students of the Department of Physics who have had only Differential and Integral Calculus.

44. **Differential Geometry II.**—General theory of surfaces and of curves on surfaces.
Mj. Spring Quarter; 9:30 A.M.
ASSOCIATE PROFESSOR MASCHKE.

Prerequisite: *Courses 17, 23, 25, and 27.*

45. **Projective Geometry.**—Based on Reye's *Geometrie der Lage.* Mj. Summer Quarter; 2:00 P.M.
HEAD PROFESSOR MOORE.

46. **Modern Analytic Geometry.** — Homogeneous (trilinear) coördinates; projective properties of conics. Mj. Autumn Quarter.
ASSOCIATE PROFESSOR MASCHKE.

Prerequisite: *Calculus* and *Theory of Equations.*

[Not to be given in '97–8.]

47. **Higher Plane Curves.**—General properties of algebraic curves; special study of the curves of the third and fourth order. Mj. Winter Quarter.
ASSOCIATE PROFESSOR MASCHKE.

Prerequisite: *Course 46.*

[Not to be given in '97–8.]

48. **Algebraic Surfaces.**—Homogeneous coördinates in space. Extension of the general theory and methods of higher plane curves to the case of three dimensions. Most important properties of algebraic surfaces of the third order and of certain other general classes of surfaces. Line geometry. Mj. Spring Quarter.
ASSOCIATE PROFESSOR MASCHKE.

Prerequisite: *Course 47.*

[Not to be given in '97–8.]

oo. **The Geometry of Lie's Transformation-Groups.**—Summer Quarter; 2 hours weekly. Monday and Thursday, 4:00 P.M.
DR. LOVETT.

Prerequisite: *Differential Geometry.*

51, 52. **Theory of Invariants I, II.**—Linear substitutions; theory of quantics ("modern higher algebra") with applications to the theory of equations and to geometry.
2 Mj. Autumn and Winter Quarters; 11:00 A.M.
PROFESSOR BOLZA.

Prerequisite: *Courses 11, 13, 15, 17, 19, and 21.*

52A. **Calculus of Variations.**—The developments of Weierstrass.
PROFESSOR BOLZA.

Prerequisite: *Course 53.*

[Not to be given in '97–8.]

53. **Theory of Functions of a Complex Variable.**—The elements of the theories of Cauchy and of Weierstrass. Mj. Winter Quarter; 8:30 A.M.
ASSOCIATE PROFESSOR MASCHKE.

Prerequisite: *Courses 19, 21, and 23.*

54. **Linear Differential Equations.**—The general theory with particular reference to differential equations of second order. Special study of the hypergeometric function.
Mj. Spring Quarter; 8:30 A.M.
ASSOCIATE PROFESSOR MASCHKE.

Prerequisite: *Course 53.*

56. **Hyperelliptic Functions.**
Mj. Summer Quarter; 11:00 A.M.
PROFESSOR BOLZA.

Prerequisite: *Course 53.*

58. **Linear Substitution Groups.**—The fundamental principles of the theory of groups will be explained at the beginning of the course. Deduction and discussion of binary, ternary and certain quaternary substitution groups of finite order.
ASSOCIATE PROFESSOR MASCHKE.

Prerequisite: *Courses 47 and 53.*

[Not to be given in '97–8.]

59. **Abstract Groups.**—With applications to various concrete group-forms.
Mj. Summer Quarter; 3:00 P.M.
HEAD PROFESSOR MOORE.

Prerequisite: No specific subjects but a facility in abstract mathematical reasoning.

60. **Theory of Substitutions,** with applications to the Theory of Algebraic Equations.
Mj. Autumn Quarter; 3:00 P.M.
HEAD PROFESSOR MOORE.

Prerequisite: *Courses 19, 21, and 53.*

61. **Theory of Numbers.**—Based on the treatises of Dirichlet-Dedekind and Bachmann.
Mj. Autumn Quarter; 2:00 P.M.
HEAD PROFESSOR MOORE.

Prerequisite: No specific subjects but a facility in abstract mathematical reasoning.

62, 63. **General Arithmetic I, II.**—The theory of integral functions of indeterminates with integral coefficients, with application to the theory of algebraic numbers and functions.
2Mj. Winter and Spring Quarters; 2:00 P.M.
HEAD PROFESSOR MOORE.

Prerequisite: *Course 61.*

70, 71. **Seminar I, II.**—Advanced students engaged in or prepared to undertake research-work may enter this Seminar. The individual members will from time to time report to the Seminar on their investigations or on assigned topics. The Seminar will consider in particular certain topics in general arithmetic, algebra, and the theory of groups. 2Mj. Winter and Spring Quarters.
Saturday, 8:30–10:30 A.M.
HEAD PROFESSOR MOORE.

THE MATHEMATICAL CLUB AND SEMINAR.

The Club meets fortnightly on Fridays at 4:00 P.M., in the Ryerson Physical Laboratory, room 35, for the review of memoirs and books, and for the presentation of results of research. The Club is conducted by the members of the Mathematical Faculty, and is open to all Graduate students of Mathematics.

PAPERS READ. 1896–97.

A twofold Generalization of Fermat's Theorem.
E. H. MOORE. April 10.

Some Physical Formulæ which are fundamental in the Theory of Functions. HARRIS HANCOCK. April 24.

The Quadratic one-to-two Transformation between two Planes.
B. M. WALKER. May 8.

On Binary Cubic Involutions and their various Geometrical Representations. O. BOLZA. May 22.

Concerning Finite Groups of Linear Homogeneous Substitutions. E. H. MOORE. July 10.

Concerning Isogonal Transformations of Space and Pentaspherical Coördinates. H. MASCHKE. July 24.

On Irrational Numbers (second paper.)
J. W. A. YOUNG. Aug. 7.

On Higher Complex Quantities. O. BOLZA. Aug. 14.

A Ternary Linear Substitution Group of Order 3.360.
G. L. BROWN. Aug. 21.

The Cross-Ratio Group of *n!* Cremona Transformations of Order *n*-3 in Flat Space of *n*-3 Dimensions.
E. H. MOORE. Aug. 28.

On a Theorem of Deruyts' in the Theory of Invariants.
O. BOLZA. Oct. 12.

Hensel's Determination of the Greatest Common Divisor of all the Integers exhibited by a Rational Integral Function of *n* Variables with Integral Coefficients.
E. H. MOORE. Oct. 12.

Concerning the Abstract Group of Order *k!* holoedrically isomorphic with the Symmetric Substitution-Group on *k* Letters E. H. MOORE. Oct. 23.

On the Factorization of Polynomials with Integral Coefficients.
HARRIS HANCOCK. Oct. 23 and Nov. 20.

Numerically Regular Reticulations on Surfaces of Deficiency higher than 1 (with illustrative Models.) PROFESSOR HENRY S. WHITE, of the Northwestern University. Nov. 6.

On the Intersection of a Straight Line and a Quadratic (*k*-1)-fold Spread in Space of *k* Dimensions. H. MASCHKE. Nov. 20

The Present State of the Problem of Three Bodies.
KURT LAVES. Dec. 4.

Concerning the Reduction of Positive Binary and Ternary Quadratic Forms. E. H. MOORE. Jan. 15.

The Accelerating Force under the Action of which a Particle free to move will describe a Conic Section.
F. R. MOULTON. Jan. 29.

Concerning the Definition of the Straight Line.
J. W. A. YOUNG. Feb. 12.

On the Reduction of a Linear Homogeneous Substitution of Finite Period to its Canonical Form.
H. MASCHKE. Feb. 26.

An Universal Invariant for Finite Groups of Linear Substitutions, with Application in the Theory of the Canonical Form of a Linear Substitution of Finite Period.
E. H. MOORE. Feb. 26.

On a Ternary Quadratic Cremona Group of Order 120.
H. E. SLAUGHT. Mar. 12.

THE UNIVERSITY EXTENSION DIVISION.

CORRESPONDENCE TEACHING DEPARTMENT.

Students who are well prepared to undertake undergraduate or graduate courses in mathematics, and who are unable to take these courses in residence may take them by correspondence under the careful guidance of competent instructors. These courses are either *formal* (the elementary undergraduate courses: set tasks) or *informal* (all advanced courses).

During the years 1892–7 courses have been given on the theory of functions of a complex variable and on selected chapters of algebra (by Head Professor Moore), on advanced and elementary differential and integral calculus and analytic geometry, plane trigonometry, college algebra and solid geometry (by Assistant Professor Hoover), and on differential equations (by Dr. Boyd).

Fees: for matriculation, five dollars ($5); for each course,* sixteen dollars ($16) quarterly. All money should be sent by draft or by money order, not by check, payable to the University of Chicago.

For calendars and circulars of information write to the Correspondence Secretary, University Extension Division, The University of Chicago.

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*Such a course is supposed to be equal to one-third of full work of a student in residence: a *Major*. It is not practicable to undertake correspondence work with students unable to devote considerable time to the work.

CONSPECTUS OF COURSES.

MATHEMATICS.

SUMMER	*AUTUMN*	*WINTER*	*SPRING*
JUNIOR COLLEGE COURSES			
1 Plane Trigonometry DM Second Term 9:30, 4:00 (*Young*) D 2 2 College Algebra 11:00 (*Slaught*) R 38	1 Plane Trigonometry 1*a* 12:00 (*Hammond*) D 2 1*b* 2:00 (*Boyd*) D 2 1*c* 9:30 (*Boyd*) D 2 3 Plane Analytics 12:00 (*Hancock*) D 2	1 Plane Trigonometry 1*a* 12:00 (*Slaught*) D 2 1*b* 2:00 (*Hancock*) D 2 2 College Algebra 2*a* 12:00 (*Hancock*) D 2 2*b* 2:00 (*Boyd*) D 2 2*c* 9:30 (*Boyd*) D 2	1 Plane Trigonometry 11:00 (*Hancock*) D 2 2 College Algebra 2*a* 12:00 (*Hancock*) D 2 2*b* 2:00 (*Slaught*) D 2 3 Plane Analytics 12:00 (*Boyd*) D 2
	Junior College Elective: Courses 11, 13, and 15 in *Calculus.*		
SENIOR COLLEGE COURSES			
10 Culture Calculus 8:30 (*Young*) D 2 12 Integral Calculus 12:00 (*Slaught*) R 38 18 Determinants M First Term 9:30 (*Young*) D 2 24 Advanced Integral Calculus 9:30 (*Bolza*) R 36	11 Calculus I 8:30 (*Boyd*) R 36 19 Equations I 11:00 (*Hancock*) R 38 23 Advanced Integral Calculus I 12:00 (*Bolza*) R 36	11 Calculus I 8:03 (*Slaught*) R 38 13 Calculus II 8:30 (*Boyd*) R 36 17 Differential Geometry I 9:30 (*Maschke*) R 38 21 Equations II 11:00 (*Hancock*) R 38 25 Advanced Integral Calculus II 12:00 (*Bolza*) R 36	13 Calculus II 12:00 (*Slaught*) R 36 15 Calculus III 8:30 (*Boyd*) R 36
GRADUATE COURSES			
30 Mathematical Pedagogy M First Term 4:00 (*Young*) R 38 35 Mathematical Reading (*Moore, Bolza*) 45 Projective Geometry 2:00 (*Moore*) R 36 00 Geometry of Transformation Groups Mon. and Thurs., 4:00 (*Lovett*) R 36 56 Hyperelliptic Functions 11:00 (*Bolza*) R 36 59 Abstract Groups 3:00 (*Moore*) R 36	35 Mathematical Reading (*Moore, Bolza*) [Astronomy 10] Analytical Mechanics I 8:30 (*Moulton*) 51 Invariants I 11:00 (*Bolza*) R 36 60 Substitutions 3:00 (*Moore*) R 36 61 Numbers 2:00 (*Moore*) R 36	35 Mathematical Reading (*Moore,Bolza,Maschke*) [Astronomy 11] Analytical Mechanics II (*Laves*) 8:30 52 Invariants II 11:00 (*Bolza*) R 36 53 Functions of Complex Variable 8:30 (*Maschke*) R 38 62 General Arithmetic I 2:00 (*Moore*) R 36 70 Seminar I Sat., 8:30–10:30 (*Moore*) R 38	35 Mathematical Reading (*Moore, Maschke*) 44 Differential Geometry II 9:30 (*Maschke*) R 38 54 Linear Differential Equations 8:30 (*Maschke*) R 38 63 General Arithmetic II 2:00 (*Moore*) R 36 71 Seminar II Sat., 8:30–10:30 (*Moore*) R 38

NOTE.—All courses are Majors unless otherwise indicated.

XVIII. THE DEPARTMENT OF ASTRONOMY

OFFICERS OF INSTRUCTION.

GEORGE E. HALE, Sc.D., *Associate Professor of Astrophysics, and Director of the Yerkes Observatory.*

SHERBURNE W. BURNHAM, A.M., *Professor of Practical Astronomy.*

EDWARD EMERSON BARNARD, A.M., Sc.D., *Professor of Practical Astronomy.*

FRANK L. O. WADSWORTH, S.B., E.M., M.E., *Assistant Professor of Astrophysics.*

THOMAS J. J. SEE, Ph.D., *Instructor in Astronomy.*[*]

KURT LAVES, Ph.D., *Instructor in Astronomy.*

FOREST RAY MOULTON, A.B., *Assistant in Astronomy.*

FERDINAND ELLERMAN, *Assistant at the Observatory.*

FELLOWS AND GRADUATE SCHOLARS.

1896-97.

WILLIAM HAMMOND WRIGHT, S.B., *Fellow in Astronomy.*

DAVID ABBOTT DREW, A.M., *Fellow in Astronomy.*

GEORGE K. LAWTON, A.B., *Graduate Scholar in Astronomy.*

INTRODUCTORY.

The approaching completion of the Yerkes Observatory enables the Department to make a somewhat fuller statement regarding the courses in Astronomy and Astrophysics than has been possible heretofore. It is obvious that for a number of reasons, the work naturally divides itself into two parts:

1. Work at the University, comprising: (*a*) Elementary instruction in general Astronomy, both theoretical and practical. (*b*) Preliminary training in the principles and methods of work underlying the science of Astrophysics, given in the undergraduate and graduate courses offered by the Department of Physics. (*c*) Graduate and research work in Celestial Mechanics, which is best developed in connection with the Department of Mathematics.
2. Graduate and research work in the Yerkes Observatory at Lake Geneva.

UNIVERSITY WORK.

In the work at the University, which will be given by Dr. Laves and Mr. Moulton, with occasional lectures by the astronomers resident at Lake Geneva, special emphasis will be laid on the development of the mathematical methods and principles which lie at the basis of the physical sciences. In addition to the annual courses in General Astronomy, Introduction to Physical Astronomy, Spherical and Practical Astronomy, Orbits and Ephemerides, Analytical Mechanics, courses in the various branches of Celestial Mechanics will be given within periods not exceeding three years. As soon as practicable the Department will extend the courses in Celestial Mechanics so as to include the theory of satellites, the lunar theory, the planetary theories of Gyldén and Poincaré, the theory of tides, and the theories of cosmogony. The most fundamental subjects will be arranged in a cyclic manner so as to recur at regular intervals, while other more special topics will vary from time to time.

The general object of the instruction will be: (1) To furnish the student an adequate mathematical basis for successful work in Physical Astronomy; (2) To give such experience and preliminary training in the work of observation and reduction, as will enable the student to use intelligently and skillfully any of the astronomical or astrophysical instruments of a modern observatory; (3) To direct the attention of advanced students to the fundamental problems of modern Astronomy and Astrophysics, and to encourage work of research likely to yield contributions to science.

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[*] On leave of absence.

OBSERVATORY WORK.

In the work at the Observatory attention will be devoted both to the investigations of Practical Astronomy and to those of Astrophysics. The rapid development of the latter science within the last few years has been fully recognized and amply provided for in the design of the Observatory and in its instrumental equipment. The special laboratory facilities will render possible many astrophysical investigations which are necessarily neglected in other institutions. The Observatory will be open to those students only who have completed the necessary preliminary work at the University or its equivalent at other institutions.

GRADUATE AND RESEARCH WORK.

Undergraduate Students, in the B.S. course, who desire to specialize along the line of Astronomy, are recommended to take *six Majors* in Mathematics, *viz.:* Differential and Integral Calculus 3; Solid Analytic Geometry 1; Advanced Integral Calculus 2; and *three Majors* in Astronomy, *viz:* General Astronomy, Introduction to Physical Astronomy, and the theory of Orbits.

Graduate Students working for the Master's degree are recommended to choose *three Majors* in the Department of Mathematics, *viz.:* Differential Equations 1; Theory of Equations 2; or in the Department of Physics, *viz.:* Advanced General Physics 3; and *six Majors* in the Department of Astronomy.

Candidates for the degree of Doctor of Philosophy are expected to make their secondary subject either Mathematics or Physics. Students intending to specialize in the lines of Astrophysics will be required to take the work in Advanced General Physics, Advanced Laboratory Practice, Laboratory Methods, and Spectrum Analysis.

SCHOLARSHIPS, FELLOWSHIPS, DOCENTSHIPS.

Graduate Scholarships, Fellowships, and Docentships, will be assigned in accordance with the general regulations of the University.

EQUIPMENT.

The Department of Astronomy at the University occupies at present rooms on the third floor of the Ryerson Physical Laboratory. For the purpose of instruction in Practical Astronomy a Students' Observatory, consisting of two small buildings, has been provided on the northeastern quadrangle. It will be equipped with an equatorial telescope, provided with both micrometer and solar and stellar spectroscope, a Bamberg universal instrument for the determination of time, latitude, and longitude, a chronometer and chronograph and various smaller accessories. The various laboratory courses offered by the Department of Physics afford the best preliminary training for the work in Astrophysics.

A description of the Yerkes Observatory at Lake Geneva and its equipment will be found on page 16 of this Programme.

LIBRARY FACILITIES.

The Astronomical Library is open to graduate students under the same conditions as the Mathematica Library, with which it is associated. The Astronomical Library includes most of the fundamental works on Physical Astronomy, several sets of annals, and the following journals:

> The Astronomical Journal, Boston; The Astrophysical Journal, Chicago; Popular Astronomy, Northfield, Minn.; Monthly Notices of the Royal Astronomical Society, London; Bulletin Astronomique, Paris; Astronomische Nachrichten, Kiel; Vierteljahrsschrift der Astronomischen Gesellschaft, Leipzig.

For a statement regarding the library of the Yerkes Observatory see page 17 of this Programme.

SEMINAR.

The Astronomical Seminar is designed for the practical investigation of particular problems. Theoretical results are here supplemented by numerical calculations.

PUBLICATIONS.

The publications of the Department are enumerated in the description of the Observatory.

COURSES OF INSTRUCTION.

M=Minor course=a single course for six weeks. DM=Double Minor course=a double course (two hours daily) for six weeks
Mj=Major course=a single course for twelve weeks. DMj=Double Major course=a double course for twelve weeks.

At The University.

I. Elementary (Senior College) Courses (1–20).

1. **Popular Lectures.**

2. **History of Astronomy.**—Introduction. The apparent motions of the heavenly bodies as explained by the ancient astronomers. The system of Copernicus. Newton's general law of gravitation, modern Astronomy.

M. First Term, Summer Quarter; 9:30 A.M.
Mj. Winter Quarter; 9:30 A.M.
Mr. Moulton.

Prerequisite: *Algebra* and *the Elements of Physics.*

3. **General Astronomy.**—An elementary course, dealing with fundamental facts, principles, and methods. Mj. Autumn Quarter; 11:00 A.M.
Mr. Moulton.

Prerequisite: *Algebra, Trigonometry,* and *the Elements of Physics.*

4. **Introduction to Physical Astronomy.**—The action of central forces; Laplace's demonstration of the law of gravitation; equations of motion; elements of the orbits; planetary integrals; invariable plane; perturbations; applications to the motion of the moon, planets and satellites; rotation of the planets, precession, and nutation.

Mj. Winter Quarter; 11:00 A.M.
Mr. Moulton.

Prerequisite: *Differential Calculus.*

6, 7. **Spherical and Practical Astronomy.** — Part I. Introduction: The principal theorems of spherical trigonometry, interpolation:

I. The different systems of polar coördinates used in Astronomy. The measurement of time.
II. Changes of the fundamental planes of reference; (1) Precession; (2) Nutation.
III. Theory of the corrections of observations due to (1) Parallax; (2) Refraction; (3) Aberration.
IV. Star catalogues and their use.

To be followed by 7.

Mj. Winter Quarter; 9:30 A.M.
Dr. Laves.

7. Part II. — With practical work in the Students' Observatory. Theory of the astronomical instruments. Determination of time and latitude, of absolute right ascensions and declinations of stars. Determination of longitude. To be preceded by 3.

Mj. Spring Quarter; 9:30 A.M.
Dr. Laves.

Prerequisite: *General Astronomy* and *Differential and Integral Calculus.*

8. **Determination of Latitude and Longitude, with practical work in the Observatory.** — Transformation of the different systems of coördinates; sidereal and mean solar time. Theory of the universal instrument; determination of its errors from observations. Determination of time and latitude by observation; theory of the determination of longitude. Mj.
Dr. Laves.

Prerequisite: *General Astronomy* and *Differential and Integral Calculus.*

[Not to be given in '97–8.]

9. **Observatory Work.** — Practice with the Equatorial and with the Universal Instrument in the Students' Observatory. Mj. Spring Quarter.
[Not to be given in '97–8.]
Mr. Moulton.

11. **Determination of the Parabolic Orbit of a Comet.**—Integration of the differential equations for the problem of two bodies. Relation between several places in the orbit; determination of the position of the orbit in space; corrections to be applied to the observed places and deduction of the elements of the orbit. Computation of an ephemeris. The theory will be applied to a special case to be selected from the list of comets recently discovered. Mj. Spring Quarter; 11:00 A.M.
Mr. Moulton.

Prerequisite: *Differential and Integral Calculus* and *General Astronomy.*

12. **Determination of an Elliptic Orbit from three Complete Observations.**—The general theory is very similar to that of (5) except that is the case of an elliptic orbit, six elements are to be determined instead of the five of a parabolic orbit. Application of the theory to the orbit of one of the small planets.

Mj. Summer Quarter; 8:30 A.M.
Dr. Laves.

Prerequisite: *Differential and Integral Calculus* and *General Astronomy.*

13. **Determination of the Orbit of a Double Star.**—Historical sketch of the different methods used. Kowalsky's method, modification proposed by Glasenapp. Graphical method of Klinkerfues.
M. Second Term, Summer Quarter; 9:30 A.M.
MR. MOULTON.

Prerequisite: *Analytical Geometry.*

14. **Theory of Probability and Method of Least Squares.** Mj.
MR. MOULTON.

Prerequisite: *Differential and Integral Calculus.*

[Not to be given in '97–8.]

II. ADVANCED (GRADUATE) COURSES (21–50).

21, 22. **Analytical Mechanics.**

21. **Statics** (*Part 1*).— Composition and equilibrium of forces applied at a point. The center of gravity of lines, surfaces, and volumes. Attraction of bodies upon a point. **Kinematics.**—Acceleration, the rectilinear and the curvilinear motion of a material point and the forces that produce them. To be followed by 22. Mj. Autumn Quarter; 8:30 A.M.
MR. MOULTON.

22. **Statics** (*Part 2*). — Composition and equilibrium of forces applied to an invariable system; principle of virtual velocities. **Dynamics.**—Principle of d'Alembert, moments of inertia; rotation of a body around an axis; general motion of a system of bodies. Rotation of a body around a point. To be preceded by 21
Mj. Winter Quarter; 8:30 A.M.
DR. LAVES.

Prerequisite: *Differential and Integral Calculus* and *Differential Equations.**

23. **Spherical Harmonics.**

I. Spherical harmonics with one variable—general theory; development of functions in spherical harmonics; spherical harmonics of the second kind and associated functions.

II. Spherical harmonics with several variables—general theory; development and properties of the functions C and S. Mj.
DR. LAVES.

[Not to be given in '97–8.]

24. **The Problem of Three Bodies.** — Introduction: (*a*) The integrals of the differential equations of a system of n bodies; (*b*) the integrals for $n=2$:

I. Lagrange's investigations. *Œuvres complètes,* VI, pp. 229–334.

II. Jacobi's investigations. *Gesammelte Werke,* IV, pp. 295–314,

III. The investigations of modern mathematicians and astronomers. Mj.
DR. LAVES.

Prerequisite: *Advanced Integral Calculus.*

[Not to be given in '97–8.]

25. **Dynamics of a System of Bodies based upon the Lectures of Jacobi.**—Differential equations of the motion of a system of material points; dynamical principles of: conservation of the motion of the center of gravity; conservation of *vis viva;* conservation of areas; principle of least action; Lagrange's multipliers; Hamilton's form of the differential equations; theorems of Jacobi. Applications of the method of Hamilton and Jacobi to mechanical problems. The theory of the variation of constants; introduction to the perturbing function. Mj.
DR. LAVES.

Prerequisite: *Differential and Integral Calculus,* and *Analytical Mechanics.*

[Not to be given in '97–8.]

31. **The Motion of a Heavenly Body in a Resisting Medium.** Mj. Autumn Quarter; 9:30 A.M.
MR. MOULTON.

Prerequisite: *Differential and Integral Calculus.*

32. **Special Perturbations.**—Numerical differentiation and integration; development of the differential equations for perturbations in rectangular and polar coördinates; variation of constants. Mj.
DR. LAVES.

Prerequisite: *Differential and Integral Calculus,* and *Elements of the Theory of Orbits.*

[Not to be given in '97–8.]

33. **Theory of Absolute Perturbations based on the Methods of Laplace.**—The differential equations for undisturbed motion, elements of the orbit; differential equations for disturbed motion; integration by successive approximation, determination of the perturbations in the radius

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*The first quarter's work in Analytical Mechanics will be open to students of the Department of Physics who have had only Differential and Integral Calculus.

vector, longitude and latitude. Development of these expressions in series adapted to the formation of planetary tables. Mj.

DR. LAVES.

[Not to be given in '97–8.]

34. **Theory of Absolute Perturbations: Lagrange's theory of variation of elements.**—Approximate Integration of the differential equations of motion. Secular values of the elements; the periodical terms of the elements. The stability of the planetary system. Long period inequalities arising from the near approach to commensurability in the mean motions. Short history of the theories of perturbations.

Mj. Summer Quarter; 7:30 A.M.

DR. LAVES.

Prerequisite: *Differential and Integral Calculus,* and *Theory of Orbits.*

35. **Gauss' Method of Determining Secular Variations, with numerical application to the action of the Earth on Mercury.**—Derivation of the formulæ for the variation of the elements; substitution of a certain form of elliptical ring which will give the same mean action as the moving planet; determination of the mutual action of two such rings by means of elliptic integrals of the first and second kinds; development of the formulæ for the secular variations of the elements as given by Hill; application of the method of Gauss to the action of Neptune on Uranus; comparison of results with those found by Leverrier from the series expanded in powers of the eccentricities and mutual inclination of the planes of the orbits. Mj. Spring Quarter; 9:30 A.M.

MR. MOULTON.

Prerequisite: *Elements of the Theory of Perturbations and of Elliptic Integrals.*

36. **Selected Chapters of Poincaré's: Les méthodes nouvelles de la mécanique céleste.** Mj.

DR. LAVES.

Prerequisite: *Course 17.*

[Not to be given in '97–8.]

41. **Theory of the Attractions and Figures of the Heavenly Bodies.**

I. Determination of the attractions of homogeneous sphere, spherical shell, heterogeneous sphere made up of layers of uniform density, homogeneous ellipsoid, spheroid of revolution differing but little from a sphere. Development of the attraction of an oblate planet in a series of spherical harmonics, following the method of Laplace.

II. Figures of equilibrium of sphere, spheroid, Jacobi's ellipsoid of three unequal axes, figures of Poincaré and Darwin. Application of the theory of the equilibrium of a fluid mass endowed with a rotatory motion to the figures of the planets.

Mj. Spring Quarter; 8:30 A.M.

DR. LAVES.

42. **Theory of a Rotating Body.**—(*a*) Euler's equations for undisturbed motion; equations of Poisson and Serret for disturbed motion, with a development of the perturbing function; precession and nutation. (*b*) Rotatory motion of a body of variable form.

Mj. Spring Quarter; 8:30 A.M.

DR. LAVES.

Prerequisite: *Differential and Integral Calculus,* and *Analytical Mechanics.*

[Not to be given in '97–8.]

50. **Astronomical Seminar.**

½Mj. Summer Quarter; Sat., 8:30–10:30 A.M.

DR. LAVES.

At the Yerkes Observatory.

In the work at the Yerkes Observatory the advanced student is made familiar with modern methods of research in various branches of Astronomy and Astrophysics. In general, the work in progress during the year 1897–8 will probably include: researches in solar physics with the spectroscope, spectroheliograph, photoheliograph and bolometer; micrometric observations of double stars, planets, satellites, nebulæ and comets; studies of stellar spectra; researches on the infra-red spectra of the elements; special astrophysical investigations. On account of the unfinished condition of the Observatory and the nature of the work, it is possible that the subjoined outline of courses will require some modification. Graduate students wishing to take any of the courses should consult the Director of the Yerkes Observatory, Williams Bay, Wis., before making a selection.

GRADUATE COURSES.

51, 52, 53. **Solar Physics.**— Visual and photographic study of the solar photosphere, spots and faculæ. Use of the photoheliograph.
DMj. Autumn Quarter.

Spectroscopic observations of Sun-spots, including systematic study of widened lines and detailed investigations of particular lines.
DMj. Winter Quarter.

Visual and photographic observations of the chromosphere, prominences and faculæ, with the solar spectroscope and spectroheliograph. Systematic records of areas; researches on special problems; measurements and reductions of photographs. DMj. Spring Quarter.
ASSOCIATE PROFESSOR HALE.

Prerequisite: *Practical Astronomy, Advanced Physics* and *Laboratory Practice, Spectrum Analysis.*

54. **Bolometric Investigations.**
Mj. Summer Quarter.
ASSOCIATE PROFESSOR HALE.

55. **Stellar Spectroscopy.**— Including measurement of motion in the line of sight and detailed studies of peculiar spectra. DMj. Autumn Quarter.
ASSOCIATE PROFESSOR HALE.

Prerequisite: *Solar Physics.*

56. **Radiometric Work.**
Mj. Summer Quarter.
ASSISTANT PROFESSOR WADSWORTH.

57. **Instrument Design and Construction.**
Mj. Summer Quarter.
ASSISTANT PROFESSOR WADSWORTH.

58. **Researches in Solar Physics.**
Mj. Summer Quarter.
ASSOCIATE PROFESSOR HALE.

59, 60, 61. **Astrophysical Research.**— Character and prerequisites will be announced later.
DMj. Autumn Quarter.
DMj. Winter Quarter.
DMj. Spring Quarter.
ASSISTANT PROFESSOR WADSWORTH.

62. **Special Research.**
Mj. Summer Quarter.
ASSISTANT PROFESSOR WADSWORTH.

THE YERKES ASTRONOMICAL OBSERVATORY.

OFFICERS OF GOVERNMENT.

GEORGE E. HALE, *Associate Professor of Astrophysics, and Director.*
SHERBURNE W. BURNHAM, *Professor of Practical Astronomy.*
EDWARD EMERSON BARNARD, *Professor of Practical Astronomy.*
FRANK L. O. WADSWORTH, *Assistant Professor of Astrophysics.*
FERDINAND ELLERMAN, *Assistant.*
G. WILLIS RITCHEY, *Optician.*
ERNEST LORENZ, *Mechanician.*

THE OBSERVATORY.

The Yerkes Observatory was founded in 1892, through the munificence of Mr. Charles T. Yerkes, of Chicago. In that year Mr. Alvan G. Clark undertook the construction of an object-glass of 40 inches aperture, for the principal telescope of the Observatory, and Messrs. Warner & Swasey were given a contract for the equatorial mounting. The latter was completed in the following year, and exhibited by its makers at the Columbian Exposition. It is similar to that of the 36-inch Lick telescope, but is heavier and more rigid, and many improvements have been introduced. An important feature, employed for the first time in this telescope, is a system of electric motors, by means of which the various motions, etc., are effected. The object-glass has been tested by Professor James E. Keeler, who acted at the request of the Director as the "expert agent" called for by the contract. The definition was found to be fully equal to that of the Lick telescope, while the light-gathering power is considerably greater.

The attachments of the Yerkes telescope will include:

1. A position micrometer, by Warner & Swasey.
2. A solar spectrograph, for micrometrical and photographic investigations of the spectra of solar phenomena.
3. A spectroheliograph, for photographing the solar chromosphere, prominences, and faculæ by monochromatic light.
4. A stellar spectrograph for researches on the spectra and motions of stars, nebulæ, comets and planets.
5. A photoheliograph for photographing the solar image on a large scale.

The construction of the main building of the Observatory was begun in April 1895. Its form is that of a Latin cross, with three domes and a meridian room at the extremities. The principal axis (about 330 feet long) of the building lies east and west, with the dome for the 40-inch telescope at the western end. This dome, which was built by Messrs. Warner & Swasey, is 90 feet in diameter, allowing ample space for the tube of the great telescope, which, with its attachments, is about 70 feet long. The elevating floor of the observing room is 75 feet in diameter, and is movable through a range of 23 feet by means of electric motors.

Of the two smaller domes, the one to the northeast contains the 12-inch telescope formerly at the Kenwood Observatory, and in the other will be mounted a 24-inch reflector. Between these domes is the heliostat room, 100 feet long by 12 feet wide. A heliostat with 24-inch plane mirror will stand on a pier at the north end of the room, under an iron roof which can be rolled away to the south.

The meridian room has double sheet-iron walls, with an intervening air space. It is designed to contain a meridian circle of large aperture, but for the present a transit instrument will suffice for the purposes of the Observatory.

The body of the building is divided through the center by a hallway extending from the meridian room to the great tower. On either side are offices and computing rooms, a library, lecture room, two spectroscopic laboratories, dark room, developing room, galvanometer room, chemical laboratory, instrument rooms, etc. In the basement is a large photographic dark room, an enlarging room, concave grating room with large concave grating spectroscope, emulsion room, constant temperature room, physical laboratory, and optician's room. The engines, dynamos, and boilers for supplying heat and power are at a distance of several hundred feet from the Observatory.

Much of the special apparatus needed for the researches conducted at the Observatory is constructed by the mechanicians under the direction of Assistant Professor Wadsworth. For this purpose a large workshop has been provided, equipped with a complete outfit of instrument-maker's tools, including an 8-inch Rivett Precision lathe, Blaisdell engine lathe, Brown & Sharpe universal milling machine, planer, drill-press, shaper, circular saw, speed-lathe, etc.

The Observatory is situated about a mile from the town of Williams Bay, near Lake Geneva, Wisconsin, in an ideal rural region, free from the dust and smoke of cities and removed from the tremors of railroad traffic. Lake Geneva is about 75 miles from Chicago, and is reached by a branch of the North-Western Railroad. The site of the Observatory includes about 50 acres of wooded land fronting on the lake. It is believed that the conditions will be favorable for the most delicate investigations in all branches of astronomy and astrophysics.

PUBLICATIONS OF THE OBSERVATORY.

The publications the Observatory will include: *Bulletins of the Yerkes Observatory*, containing announcements of results and discoveries, brief descriptions of new buildings and instruments, and notes on the work of the Observatory (*Bulletin No. 1*, on the "Organization of the Yerkes Observatory," has already been published); *Contributions from the Yerkes Observatory*, consisting of papers contributed to various astronomical and astrophysical periodicals and the proceedings of societies; *Annals of the Yerkes Observatory* in the form of quarto volumes containing detailed accounts of special researches; and *The Astrophysical Journal*, an International Review of Spectroscopy and Astronomical Physics (now in its sixth volume: see Part VIII of the ANNUAL REGISTER.)

OBSERVATORY LIBRARY.

The library contains sets of many of the astronomical periodicals, charts, star catalogues, annals of observatories, and numerous general works. The following periodicals are regularly received: Astronomische Nachrichten, American Journal of Science, Astrophysical Journal, Publications of the Astronomical Society of the Pacific, American Chemical Journal, Astronomical Journal, Bulletin de la Société Astronomique de France, Proceedings of the American Association for the Advancement of Science, Proceedings of the American Academy of Arts and Sciences, Archives des Sciences Physiques et Naturelles Annalen der Physik und Chemie, Beiblätter zu den Annalen der Physik und Chemie, Vierteljahrsschrift der Astronomischen Gesellschaft, Journal of the British Astronomical Association, Bulletin Astronomique, Photo-Beacon, Comptes Rendus de l'Académie des Sciences de Paris, Engineering, Journal of the Franklin Institute, Himmel und Erde, Johns Hopkins University Circulars, Zeitschrift für Instrumentenkunde, Knowledge, Monthly Notices and Memoirs of the Royal Astronomical Society, The Monist, American Meteorological Journal, Terrestrial Magnetism, Journal of Geology, Annals of Mathematics, American Journal of Mathematics, Bulletin of the American Mathematical Society, Zeitschrift für Mathematik und Physik, Monthly Weather Review, Nature, The Observatory, Wilson's Photographic Magazine, Anthony's Photographic Bulletin, Photographic Times, Journal de Physique, Popular Astronomy, Philosophical Magazine, British Journal of Photography, Physical Review, Proceedings of the Royal Society, Proceedings of the Royal Institution, Memorie della Società degli Spettroscopisti Italiani, Scientific American Supplement, Sirius, Science, Technology Quarterly, Bulletins de l'Académie Royale de Belgique, Verslagen van de Zittingen der Koninklijke Akademie van Wetenschappen, Amsterdam, etc.

The Officers of the Department of Astronomy will be glad to answer inquiries from institutions looking for well-equipped teachers of Astronomy.

Letters of inquiry and requests for documents should be addressed to

THE EXAMINER,
THE UNIVERSITY OF CHICAGO,
Chicago, Ill.

CONSPECTUS OF COURSES.

ASTRONOMY.

SUMMER	*AUTUMN*	*WINTER*	*SPRING*
SENIOR COLLEGE COURSES			
2 History of Astronomy M First Term 9:30 (*Moulton*) 12 Elliptic orbit (small planet) 8:30 (*Laves*) 13 Orbit of a Double Star M Second Term 9:30 (*Moulton*)	3 General Astronomy 11:00 (*Moulton*)	2 History of Astronomy 9:30 (*Moulton*) 4 Physical Astronomy 11:00 (*Moulton*) 6 Spherical and Practical Astronomy I 9:30 (*Laves*)	7 Spherical and Practical Astronomy II 9:30 (*Laves*) 11 Determination of a Parabolic Orbit 11:00 (*Moulton*)
GRADUATE COURSES			
34 Absolute Perturbations: Variation of Elements 7:30 (*Laves*) 50 Astronomical Seminar ½Mj Sat., 8:30–10:30 (*Laves*) 54 Bolometric Investigations* (*Hale*) 56 Radiometric Work* (*Wadsworth*) 57 Instrument Design and Construction* (*Wadsworth*) 58 Researches in Solar Physics* (*Hale*) 62 Special Research* (*Wadsworth*)	21 Analytical Mechanics I 8:30 (*Moulton*) 31 The Motion of a Heavenly Body in a Resisting Medium 9:30 (*Moulton*) 51 Solar Physics* DMj (*Hale*) 55 Stellar Spectroscopy* DMj (*Hale*) 59 Astrophysical Research* DMj (*Wadsworth*)	22 Analytical Mechanics II 8:30 (*Laves*) 52 Solar Physics* DMj (*Hale*) 60 Astrophysical Research* DMj (*Wadsworth*)	41 Theory of the Attractions and Figures of the Heavenly Bodies 8:30 (*Laves*) 35 Gauss' Method of Secular Variations 9:30 (*Moulton*) 53 Solar Physics* DMj (*Hale*) 61 Astrophysical Research* DMj (*Wadsworth*)

* Hours to be arranged with instructor.

Mote.—All courses are Majors unless otherwise indicated.

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PROGRAMME

OF THE

DEPARTMENT OF CHEMISTRY

1898-99

CHICAGO
The University of Chicago Press
1898

XX. THE DEPARTMENT OF CHEMISTRY.

OFFICERS OF INSTRUCTION.

JOHN ULRIC NEF, Ph.D., *Head Professor of Chemistry.*
ALEXANDER SMITH Ph.D., *Associate Professor of General Chemistry.*
FELIX LENGFELD, Ph.D., *Assistant Professor of Inorganic Chemistry.*
JULIUS STIEGLITZ, Ph.D., *Assistant Professor of Chemistry.*
MASSUO IKUTA, Ph.D., *Instructor in Chemistry.*
LAUDER W. JONES, Ph.D., *Assistant in Chemistry.*
JAMES H. RANSOM, A.M., *Lecture Assistant.*

FELLOWS.

1897-98.

FRED NEHER, A.M.
HERBERT N. McCOY, S.M.
HENRY C. BIDDLE, A.M.

INTRODUCTORY.

The lecture and laboratory instruction will be adapted to the wants of beginners as well as the most advanced students. Lectures will be given regularly on General Chemistry, Analytical Chemistry, Theoretical and Physical Chemistry, and advanced Inorganic and Organic Chemistry. Special courses on selected topics will also be given, which will vary from year to year. The chief instruction in every course will, however, be given in the laboratory, as far as the nature of the subject will admit. Only in exceptional cases will students be allowed to hear lectures without taking the corresponding laboratory course. Special stress will be placed on thorough preparation and symmetrical development of the student's knowledge. The object of the courses will be not so much to train specialists as to prepare the student to undertake intelligibly any and every kind of work of a chemical nature. They will, therefore, at present be adapted rather to those looking forward to a career as scientists or teachers, yet it is unquestionable that those intending to become practical chemists will find a thorough course of purely scientific chemistry the best basis for future specialization in any direction whatever. Those who incline towards inorganic chemistry will, therefore, be required to do a considerable amount of organic work, and those proposing to become organic chemists will be required to do work in inorganic chemistry of a more advanced nature than that given in the elementary and analytical courses. (For description of the Kent Chemical Laboratory see page 10 of this Programme.)

RESEARCH WORK.

Students offering themselves as candidates for the degree of Doctor of Philosophy must not only observe the general rules of the University in regard to this degree, but must also satisfy the instructors in the different chemical branches that their previous training has been a broad one, and no degree of proficiency in a special branch will be accepted as the equivalent of this. The candidates will at once undertake research, either in Inorganic, Organic, or Physical Chemistry, under the supervision of one of the instructors or docents. The degree will be conferred only after presenting a thesis embodying the results of a satisfactory amount of work which must be a real contribution to knowledge, and after passing an examination on the general field of chemistry, as well as examinations on one or more secondary, but allied, subjects.

INDEPENDENT WORK.

Special opportunities to pursue entirely independent research work will be given to maturer students who have already obtained the doctor's degree. After completion of a sufficient amount of creditable work, and presentation of a thesis embodying the results obtained, such students may be admitted as *docents*, thereby receiving the right to lecture, give laboratory instruction and supervise research work in the Chemical Department of the University. Students of this class, as well as others, intending to engage in independent research, are requested to make known their special requirements as early as possible, in order that the requisite materials which are not always accessible in America, may be obtained without delay.

SPECIAL STUDENTS.

Special students, not candidates for a degree, will be received, and will be given every possible facility, but in every case they will be required to give evidence, satisfactory to the instructors in the different branches, that their previous training has been sufficient, both in latitude and amount, to enable them to derive full profit from the courses they propose to take.

SEMINAR WORK.

A Chemical Seminar will be held, usually bi-weekly, in which instructors and all advanced students will take part, and in which recent chemical work will be presented and discussed, and informal lectures given on various topics of interest to chemists.

PREREQUISITES.

A good reading knowledge of French and German is desirable for Courses 9–17, and will be required for Courses 18–42.

Candidates for the degree of Doctor of Philosophy must have taken the first course in General Physics, and they are strongly advised to take the second course in Experimental Physics, which calls for the calculus as a prerequisite. They must also take courses in Crystallography and Mineralogy.

FELLOWSHIPS.

University fellowships yielding an income of $320 or $520 annually are open to graduate students in chemistry. The appointments to these fellowships will be based exclusively on merit. A fellow will be expected to render assistance to the Department in serving as an assistant at lectures or in the laboratory. In no case, however, will he be required, or allowed, to devote more than one-sixth of his time to such service.

PUBLICATIONS.

The scientific work carried out in the laboratory will be published in various existing periodicals as "Contributions from the Kent Chemical Laboratory of the University of Chicago." Owing to the fact that a journal devoted to pure scientific work in chemistry already exists in the country, it is deemed unnecessary to edit a departmental journal, but it is likely that the dissertations for a doctor's degree, carried out in the Department, may be published from time to time in the form of "Studies from the Kent Chemical Laboratory."

LIBRARY FACILITIES.

The Department is equipped with an almost complete list of periodicals, past and current, necessary for prosecuting research; it also possesses a large number of reference and handbooks.

The following periodicals are received by the Department:

> American Chemical Journal; Journal of the Chemical Society (London); Chemical News; Berichte der Deutschen Chemischen Gesellschaft; Liebig's Annalen; Zeitschrift für Analytische Chemie; Zeitschrift für Anorganische Chemie; Zeitschrift für Physikalische Chemie; Journal of the American Chemical Society; Journal of Physical Chemistry; Journal für Praktische Chemie; Monatshefte für Chemie; Chemiker Zeitung; Chemisches Centralblatt; Jahrbuch der Chemie; Jahresbericht über die Fortschritte der Chemie; Annales de Chimie et de Physique; Bulletin de la Société chimique de Paris; Recueil des Travaux chimiques des Pays-Bas; Gazetta Chimica Italiana.

A number of general scientific journals and many of the proceedings of learned societies are received in the General Library.

COURSES OF INSTRUCTION.

M=Minor course=a single course for six weeks. DM=Double Minor course=a double course (two hours daily) for six weeks. Mj=Major course=a single course for twelve weeks. DMj=Double Major course=double course for twelve weeks.

PRIMARILY FOR THE JUNIOR COLLEGES.

1, 2, 3. **General Inorganic Chemistry.**—Autumn, Winter and Spring Quarters, class room 3 hrs. a week, 12:00; laboratory 6 hrs. a week 2:00–5:00. 3Mj.

ASSOCIATE PROFESSOR SMITH.

This is a continuous course through three Quarters.

1A, 2A, 3A. **General Inorganic Chemistry.**—Autumn, Winter and Spring Quarter, class room 3 hrs. a week 12:00. 1½Mj.

ASSOCIATE PROFESSOR SMITH.

The class-room work of 1, 2, 3.

4. **General Inorganic Chemistry.**—Summer Quarter, '98, lectures 6 hrs. a week, 11:00; laboratory work 12 hrs. a week, 2:00–5:00. DMj.

ASSISTANT PROFESSOR LENGFELD.

4A. **General Inorganic Chemistry.**—Summer Quarter, Class room 6 hrs. a week, 11:00. 1Mj.

ASSISTANT PROFESSOR LENGFELD.

The class-room work of 4.

5. **General Chemistry.**—Chiefly laboratory work.

Mj. Autumn Quarter, '98.

ASSOCIATE PROFESSOR SMITH.

Sequel to Course 4 and with it equivalent to Courses 1, 2, 3.

Courses 1 and 4 must be preceded by Preparatory (entrance) Physics or its equivalent, including some laboratory work.

1B, 2B. **General Inorganic Chemistry.**—Autumn and Winter Quarters '98–9, class room 3 hrs. a week, 12:00; laboratory 6 hrs. a week, 2:00–5:00. 2Mj.

ASSOCIATE PROFESSOR SMITH.

This course is open only to students having credit for entrance chemistry and physics.

The aim of the equivalent continuous Courses 1, 2, 3; 4, 5; and 1B, 2B will be to give a definite idea of the fundamental principles of chemistry, and not to overburden the student with a mass of unconnected facts. The lectures will be experimental to a considerable extent. A knowledge of the characteristic properties of the more common elements and their compounds will be acquired. The course is designed to meet the wants, not only of those who wish to go deeper into chemistry, but of all who wish to secure a liberal education.

NOTE.—Two hours of laboratory are reckoned as equal to one hour of lecture work.

PRIMARILY FOR THE SENIOR COLLEGES.

6, 7. **Qualitative Analysis.**—Chiefly laboratory work. The instructor may at any time substitute one hour of class-room work for two hours of laboratory work.

2 Mj. or 2DM. 8 or 16 hrs. a week laboratory. 2 hrs. a week class room.

Autumn and Winter Quarters, and First Term of Summer Quarter, '98.

Lectures: 2:00.

ASSISTANT PROFESSOR STIEGLITZ.

DR. JONES or MR. MCCOY assisting in the Laboratory.

Spring Quarter, '99.

ASSISTANT PROFESSOR LENGFELD.

Second Term of Summer Quarter, '98.

DR. JONES.

Prerequisite: *Courses 1, 2, 3,* or *4 and 5,* or *1B and 2B.*

Courses 6, 7, 8 form a continuous course, which may be begun in any quarter.

The aim in Courses 6, 7, 8 will be to train the student to do intelligent analytical work and to enable him to analyze, at the end of the course, without the use of a book or table, any mixture containing common inorganic compounds.

9, 10. **Quantitative Analysis.** — Chiefly laboratory work in volumetric and gravimetric analysis.

2Mj or 2DM. 10 or 20 hrs. a week.

Autumn and Winter Quarters, and First Term of Summer Quarters, '98.

ASSISTANT PROFESSOR STIEGLITZ.

DR. JONES or MR. MCCOY assisting in the Laboratory.

Spring Quarter, '99.

ASSISTANT PROFESSOR LENGFELD.

Second Term of Summer Quarter, '98.

DR. JONES.

Prerequisite: *Qualitative Analysis.*

Courses 9, 10, 11 form a continuous course, which may be begun in any quarter.

PRIMARILY FOR THE GRADUATE SCHOOL.

8. **Advanced Qualitative Analysis.**—Mj or DM. 8 or 16 hrs. a week, laboratory; 2 hrs. a week class room.

Autumn and Winter Quarters, and First Term of Summer Quarter, '98.

ASSISTANT PROFESSOR STIEGLITZ.

Spring Quarter, '99.

ASSISTANT PROFESSOR LENGFELD.

Second Term of Summer Quarter, '98.

DR. JONES.

Open to College Students. Continuation of Courses 6 and 7.

11. **Advanced Quantitative Analysis.** — Mj or DM 10 or 20 hrs. a week.

Autumn and Winter Quarters, and First Term of Summer Quarter, '98.

ASSISTANT PROFESSOR STIEGLITZ.

Spring Quarter, '99

ASSISTANT PROFESSOR LENGFELD.

Second Term of Summer Quarter, '98.

DR. JONES.

Continuation of Courses 9 and 10. Open to students in the Senior College.

12. **Elementary Spectrum Analysis (Qualitative)** Emission (flame and electric spark) and absorption spectra of inorganic substances. Chiefly laboratory work.

½ Mj. Winter Quarter, '99.

DR. JONES.

13. **Special Methods in Quantitative Analysis.**—Special analysis of water, ores, minerals, etc.; gas analysis; analysis by electrolytic methods. Chiefly laboratory work.

Autumn and Winter Quarters and First Term of Summer Quarter.

ASSISTANT PROFESSOR STIEGLITZ.

Prerequisite: *Quantitative Analysis.*

Candidates for the degree of Ph.D. intending to pursue research work in inorganic chemistry will be required to take 2DM or 2Mj of this course; those intending to pursue research work in organic chemistry will be required to take one DM or Mj.

14, 15, 16. **Organic Chemistry.**—The compounds of carbon, including the fatty and the aromatic series. The aim of the course will be to take up very thoroughly the simpler compounds, going with great detail into the chemical behavior, the characteristic reactions and relationships of the different classes of organic compounds, and considering the synthetic methods by which they can be obtained, with great care. Richters *Organic Chemistry* is used as a reference book, but recent literature will, in special cases, be considered in detail. Lectures.

5M. Autumn and Winter Quarters, '98–9, and First Term of Spring Quarter, '99; 12:00.

HEAD PROFESSOR NEF.

Prerequisite: *General Chemistry and Qualitative Analysis.*

17. **General Organic Chemistry.**—Fatty and aromatic series.

Lectures, 5 hrs. a week. Mj.

Summer Quarter, '98; 8:30.

DR. JONES.

Prerequisite: *General Chemistry and Qualitative Analysis.*

18, 19, 20. **Organic Preparations.** — Laboratory work, 10 or 20 hrs. a week. M or DM.

Autumn and Winter Quarters, and First Term of Spring Quarter, '98–9.

Second Term of Summer Quarter, '98.

HEAD PROFESSOR NEF.

Second Term, Spring Quarter, '99.

ASSOCIATE PROFESSOR SMITH.

Prerequisite: *Qualitative and Quantitative Analysis*, *Mineralogy* (for candidates for the degree of Ph.D.), and *Organic Chemistry* (it may be taken simultaneously in connection with lectures on Organic Chemistry). Those intending to pursue research work in Inorganic Chemistry will be required to take 2DM of this course and those intending to pursue research work in Organic Chemistry will be required to take the 3DM. A reading knowledge of French and German is essential.

21, 22. **Organic Preparations.**—Laboratory work. 10 or 20 hrs. a week. M or DM.

First Term, Summer Quarter, '98.

DR. JONES.

Prerequisite: *as in Course 18.*

23. **Advanced General Chemistry.** — Causes of and conditions for chemical action. 4 hrs. a week.

Mj. Spring Quarter, '99; 8:30.

ASSOCIATE PROFESSOR SMITH.

Prerequisite: *College Physics, General Chemistry and Qualitative Analysis.*

24. **Advanced Inorganic Chemistry.**—Two lectures a week on selected topics. ½Mj.

Autumn Quarter, '98.

ASSISTANT PROFESSOR LENGFELD.

Prerequisite: *General Chemistry and Qualitative Analysis.*

25, 26, 27. **Inorganic Preparations.**—Laboratory work. 2 or 3DM, or 2 or 3 Mj. 10 or 20 hrs. a week.

Summer, Autumn, and Spring Quarters, and First Term of Winter Quarter, '98–9.

ASSISTANT PROFESSOR LENGFELD.

Prerequisite: *Qualitative and Quantitative Analysis, and a reading knowledge of French and German.*

Those intending to pursue research work in Organic Chemistry will be required to take 2DM of this course; those intending to engage in Inorganic Research will be required to take 3DM.

31, 32. **Theoretical Chemistry.**—With special reference to physical methods. 3 hrs. a week.

3M. Autumn Quarter and First Term of Winter Quarter, '98–9; 8:30.

ASSISTANT PROFESSOR LENGFELD.

Prerequisite: *College Physics and General Chemistry.*

33. **Research Work for Ph.D. Thesis.**—This course will include from 30 to 40 hrs. a week of laboratory work, under the special direction of some one of the instructors in the department. It is expected that a student will be occupied for a period of 4–8 quarters, 4–8 DMj.

33*a*. RESEARCH IN ORGANIC CHEMISTRY.—Second Term of Summer Quarter, Autumn and Winter Quarters, and First Term of Spring Quarter.

HEAD PROFESSOR NEF.

33*b*. RESEARCH IN GENERAL CHEMISTRY.

Autumn, Winter, and Spring Quarters

ASSOCIATE PROFESSOR SMITH.

33*c*. RESEARCH IN INORGANIC CHEMISTRY.—All Quarters.

ASSISTANT PROFESSOR LENGFELD.

33*d*. RESEARCH IN ORGANIC CHEMISTRY.—Autumn and Winter Quarters, First Term of Summer Quarter.

ASSISTANT PROFESSOR STIEGLITZ.

Before being admitted to Research, a candidate must satisfy the instructors of the department, by an oral test, or otherwise, that his or her previous training has been sufficient.

A candidate for the degree of Ph.D. must have taken Courses 1, 2, 3 (or 4, 5), (or 1*B*, 2*B*) 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 31, 32; the amount required of courses 18, 19, 20 and 25, 26, 27; as well as at least eight ½Mj among the special Courses 12, 23, 24, 34, 35, 36, 37, 38, 39, 40, 41, 42, or their equivalent.

34. **Physico-Chemical Methods.** — Determination of specific gravity, molecular weights, etc. Laboratory work 5 hrs. a week.

M. First Term of Winter Quarter, '99.

ASSISTANT PROFESSOR LENGFELD.

35. **The Carbohydrates and Complex Hydrocarbons,** (including the terpenes) and their derivatives.

Lectures, 2 hrs. a week. ½Mj. Autumn Quarter, '98.

ASSISTANT PROFESSOR STIEGLITZ.

Prerequisite: *Organic Chemistry.*

36. **Organic Nitrogen Derivatives.**—Uric acid series; pyridine, pyrazol, quinone-imides, and phenazine compounds; a discussion of the alkaloids, ptomaines, and organic dye-stuffs.

Lectures, 2 hrs. a week.

½Mj. Winter Quarter, '99.

ASSISTANT PROFESSOR STIEGLITZ.

Prerequisite: *Organic Chemistry.*

37. **Special Chapters of Organic Chemistry.**— Lectures, 4 hrs. a week.

M. Second Term, Summer Quarter, '98; 12:00.

HEAD PROFESSOR NEF.

Prerequisite: *Organic Chemistry.*

38. **The Aromatic Series.**—Lectures, 2 hrs. a week. ½Mj. Winter Quarter, 1900.

ASSISTANT PROFESSOR STIEGLITZ.

Prerequisite: *Organic Chemistry.*

40, 41. **The Chemistry of Coal Tar Colors.**

1 hr. a week, two ½ Mj. Autumn and Winter Quarters, '98–9. DR. IKUTA.

42. **History of Chemistry.** — 2 hrs. a week. Winter and Spring Quarters. Two ½ Mj.

[Not to be given in '98–9.]

43. **Journal Meetings.**

Autumn and Winter Quarters.

HEAD PROFESSOR NEF.

All candidates for the degree of Ph.D., more advanced students, docents and instructor, will be present and take part in turn, in presenting and discussing recent investigations. Meetings will be held on alternate Fridays from 5:00 to 6:00. They may be attended by anyone interested, whether connected with the University or not; the subjects for the meetings will be announced at least one week beforehand.

CONSPECTUS OF COURSES.

CHEMISTRY.

NOTE.—Laboratory Fees are due in addition to the Tuition Fees for all laboratory courses in the Chemistry Department as follows: Minor courses, $2.50; Major or Double Minor Courses, $5.00; Double Majors, $10.00.

SUMMER	*AUTUMN*	*WINTER*	*SPRING*
JUNIOR COLLEGE COURSES			
4 General Chemistry DMj Lectures: **Mon.–Sat. 11:00** Laboratory: (after one week) **Mon.–Thurs. 2:00–5:00** (*Lengfeld*) 4A General Chemistry Mj **Mon.–Sat. 11:00** Lectures of Course 4	1 General Chemistry, continued in Winter and Spring Quarters Mj **Mon.–Wed. 12:00** Laboratory: **Thurs. & Fri. 2:00–5:00** (*Smith*) Students having credit for entrance Chemistry, take 1B 1B General Chemistry, concluded in Winter Quarter Mj **Mon.–Wed. 12:00** Laboratory: **Thurs. & Fri. 2:00–5:00** (*Smith*) 5 General Chemistry Mj (*Smith*) (Sequel to Course 4)	2 General Chemistry Second Quarter Mj **Mon.–Tues. 12:00** Laboratory: **Wed.–Fri. 2:00–5:00** (*Smith*) 2B General Chemistry, sequel to 1B Mj **Mon.–Tues. 12:00** Laboratory: **Wed.–Fri. 2:00–5:00** (*Smith*)	3 General Chemistry Third Quarter Mj **Mon.–Wed. 12:00** **Thurs. & Fri. 2:00–5:00** (*Smith*)
SENIOR COLLEGE COURSES			
†6, 7 Qualitative Analysis M or DM Lectures: **Mon. and Thurs. 2:00** First Term (*Stieglitz*) Second Term (*Jones*) †9, 10 Quantitative Analysis M or DM First Term (*Stieglitz*) Second Term (*Jones*)	†6, 7 Qualitative Analysis Mj or DM Lectures: **Mon. and Thurs. 2:00** (*Stieglitz*) Prerequisite: XX-3 or 4 or 5A †9, 10 Quantitative Analysis Mj or DM (*Stieglitz*) Prerequisite: XX-7 or 8	†6, 7 Qualitative Analysis Mj or DM Lectures: **Mon. and Thurs. 2:00** (*Stieglitz*) Prerequisite: XX-3 or 4 or 5A †9, 10 Quantitative Analysis Mj or DM (*Stieglitz*) Prerequisite: XX-7 or 8	†6, 7 Qualitative Analysis Mj or DM Lectures: **Mon. and Thur. 2:00** (*Lengfeld*) Prerequisite: XX-3 or 5A †9, 10 Quantitative Analysis Mj or DM (*Lengfeld*) Prerequisite: XX-7 or 8

† Courses 6, 7, and 8 constitute three quarters' work and may be begun any quarter. The student registering for his first quarter's work in Qualitative Analysis registers for 6; for his second quarter's work, for 7; for his third quarter's work, for 8. Any one of these courses may be taken as a Mj. or as a DM. The same arrangement holds for Courses 9, 10, and 11.

CHEMISTRY.—*Continued.*

SUMMER	*AUTUMN*	*WINTER*	*SPRING*
GRADUATE COURSES			
8 Advanced Qualitative Analysis M or DM First Term (*Stieglitz*) Second Term (*Jones*)	1A General Chemistry Class room work of 1 ½Mj **Mon.–Wed. 12:00** (*Smith*)	2A General Chemistry Class room work of 2 ½Mj **Mon.–Tues. 12:00** (*Smith*)	3A General Chemistry Class room work of 3 ½Mj **Mon.–Wed. 12:00** (*Smith*)
11 Advanced Quantitative Analysis M or DM First Term (*Stieglitz*) Second Term (*Jones*)	8 Advanced Qualitative Analysis Mj or DM (*Stieglitz*)	8 Advanced Qualitative Analysis Mj or DM (*Stieglitz*)	8 Advanced Qualitative Analysis Mj or DM (*Lengfeld*)
13 Special Methods in Quantitative Analysis M or DM First Term (*Stieglitz*)	11 Advanced Quantitative Analysis Mj or DM (*Stieglitz*)	11 Advanced Quantitative Analysis Mj or DM (*Stieglitz*)	11 Advanced Quantitative Analysis Mj or DM (*Lengfeld*)
17 Organic Chemistry Mj **Mon.–Fri. 8:30** (*Jones*)	13 Special Methods in Quantitative Analysis Mj or DMj (*Stieglitz*)	12 Elementary Spectrum Analysis ½Mj (*Jones*)	16 Organic Chemistry M First Term **Thurs.–Sat. 12:00** (*Nef*)
18, 19, 20 Organic Preparations DM or M Second Term (*Nef*)	14 Organic Chemistry Mj **Thurs.–Sat. 12:00** (*Nef*)	13 Special Methods in Quantitative Analysis Mj or DMj (*Stieglitz*)	†18, 19, 20 Organic Preparations M or DM First Term (*Nef*)
†21, 22 Organic Preparations DM or M First Term (*Jones*)	†18, 19, 20 Organic Preparations Mj or DM (*Nef*)	15 Organic Chemistry Mj **Thurs.–Sat. 12:00** (*Nef*)	†18, 19, 20 Organic Preparations M or DM Second Term (*Smith*)
†25, 26, 27 Inorganic Preparations Mj or DM (*Lengfeld*)	24 Advanced Inorganic Chemistry ½Mj (*Lengfeld*)	†18, 19, 20 Organic Preparations Mj or DM (*Nef*)	23 Advanced General Chemistry Mj **Mon.–Thurs. 8:30** (*Smith*)
33*a* Research DM Second Term (*Nef*)	†25, 26, 27 Inorganic Preparations Mj or DM (*Lengfeld*)	†25, 26, 27 Inorganic Preparations DM First Term (*Lengfeld*) Prerequisites: XX-8, 11	†25, 26, 27 Inorganic Preparations Mj or DM (*Lengfeld*)
33*c* Research DMj (*Lengfeld*)	31 Theoretical Chemistry ½Mj **Tues. and Fri. 8:30** (*Lengfeld*)	32 Theoretical Chemistry M First Term (*Lengfeld*) Prerequisite: XX-8	33*a* Research DM First Term (*Nef*)
33*d* Research DM First Term (*Stieglitz*)	33*a* Research DMj (*Nef*)	33*a* Research DMj (*Nef*)	33*b* Research DMj (*Smith*)
37 Special Chapters of Organic Chemistry M Second Term **Wed–Sat. 12:00** (*Nef*)	33*b* Research DMj (*Smith*)	33*b* Research DMj (*Smith*)	33*c* Research DMj (*Lengfeld*)
	33*c* Research DMj (*Lengfeld*)	33*c* Research DM First Term (*Lengfeld*)	
	33*d* Research DMj (*Stieglitz*)	33*d* Research DMj (*Stieglitz*)	
	36 Organic Nitrogen Derivatives ½Mj **Mon. and Thurs. 8:30** (*Stieglitz*)	34 Physico-Chemical Methods M First Term (*Lengfeld*) Prerequisite: XX-31	
	40 Coal Tar Colors ½Mj (*Ikuta*)	35 Carbohydrates ½Mj **Mon. and Thurs. 8:30** (*Stieglitz*) Prerequisite: XX-16 or 17	
	43 Journal Meeting **Fri. 5:00** (*Nef*)	41 Coal Tar Colors ½Mj (*Ikuta*)	
		43 Journal Meeting **Fri. 5:00** (*Nef*)	

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†Courses 18, 19, and 20 constitute three quarter's work, and may be begun any quarter. The student registering for his first quarter's work in Organic Preparations registers for 18; for his second quarter's work, for 19; for his third quarter's work, for 20. Any one of these courses may be taken as a Mj. or as a DM. The same principles apply to 25, 26, and 27.

NOTE.—All courses are Majors unless otherwise indicated.

THE KENT CHEMICAL LABORATORY.

OFFICERS OF GOVERNMENT.

JOHN ULRIC NEF, *Head Professor of Chemistry and Director.*
ALEXANDER SMITH, *Associate Professor of General Chemistry.*
FELIX LENGFELD, *Assistant Professor of Inorganic Chemistry.*
JULIUS STIEGLITZ, *Assistant Professor of Chemistry.*
MASSUO IKUTA, *Instructor in Chemistry.*
LAUDER W. JONES, *Assistant in Chemistry.*
JAMES H. RANSOM, *Lecture Assistant.*

THE BUILDING.

The Chemical Laboratory, provided by the generosity of Mr. Sidney A. Kent, was opened January 1, 1894.

The rooms are arranged as follows:

The *basement* contains a furnace room, with a set of gas furnaces, with air blast of the most modern construction, for crucible work, muffle work, tube heating, and other purposes, a constant temperature room, a room fitted with steam and other appliances for work on a large scale, a mechanical workshop, and storage rooms.

On the *first floor* are one small and two large lecture rooms, and a large lecture hall seating three hundred persons, fitted for use as a chemical lecture room, if desired. This floor also contains a chemical museum, a large private laboratory, a room with northern exposure, especially fitted for use as a gas analysis laboratory, and also apparatus and preparation rooms connected with the lecture rooms.

On the *second floor* are two large laboratories intended for research and advanced work, three private laboratories for the professors, balance, combustion, air furnace, and storerooms, a balcony for out-of-door work, and the chemical library, which contains full sets of the most important journals, as well as the most important text-books and other works relating to chemistry.

On the *third floor* are three large laboratories for general and analytical chemistry, a storeroom, a preparation room, a room especially fitted for optical and photographic work, a balance room, and a private laboratory. The most modern system of ventilation has been adopted, air of constant temperature being forced in by fans from below, and withdrawn by a fan above. The building will be lighted throughout by electric lights, and the laboratories will be provided with electricity adapted to every kind of electro-chemical work.

The fullest opportunity will be given for doing research work. All possible aid will be afforded those who desire to avail themselves of the facilities of the laboratory.

The Officers of the Department of Chemistry will be glad to answer inquiries from institutions looking for well-equipped teachers in Chemistry.

Letters of inquiry and requests for documents should be addressed to

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XX. *THE DEPARTMENT OF CHEMISTRY.*

OFFICERS OF INSTRUCTION.

JOHN ULRIC NEF, PH.D., *Professor and Head of the Department of Chemistry.*
ALEXANDER SMITH, PH.D., *Associate Professor of General Chemistry.*
FELIX LENGFELD, PH.D., *Assistant Professor of Inorganic Chemistry.*
JULIUS STIEGLITZ, PH.D., *Assistant Professor of Chemistry.*
MASSUO IKUTA, PH.D., *Instructor in Chemistry.*
LAUDER W. JONES, PH.D., *Assistant in Chemistry.*
JAMES H. RANSOM, A.M., *Lecture Assistant.*
HERBERT N. McCOY, PH.D., *Laboratory Assistant.*

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INTRODUCTORY.

The lecture and laboratory instruction will be adapted to the wants of beginners as well as the most advanced students. Lectures will be given regularly on General Chemistry, Analytical Chemistry, Theoretical and Physical Chemistry, and advanced Inorganic and Organic Chemistry. Special courses on selected topics will also be given, which will vary from year to year. The chief instruction in every course will, however, be given in the laboratory, as far as the nature of the subject will admit. Only in exceptional cases will students be allowed to hear lectures without taking the corresponding laboratory course. Special stress will be placed on thorough preparation and symmetrical development of the student's knowledge. The object of the courses will be not so much to train specialists as to prepare the student to undertake intelligibly any and every kind of work of a chemical nature. They will, therefore, at present be adapted rather to those looking forward to a career as scientists or teachers; yet it is unquestionable that those intending to become practical chemists will find a thorough course of purely scientific chemistry the best basis for future specialization in any direction whatever. Those who incline towards inorganic chemistry will, therefore, be required to do a considerable amount of organic work, and those proposing to become organic chemists will be required to do work in inorganic chemistry of a more advanced nature than that given in the elementary and analytical courses. (For description of the Kent Chemical Laboratory see page 10 of this PROGRAMME.)

RESEARCH WORK.

Students offering themselves as candidates for the degree of Doctor of Philosophy must not only observe the general rules of the University in regard to this degree, but must also satisfy the instructors in the different chemical branches that their previous training has been a broad one, and no degree of proficiency in a special branch will be accepted as the equivalent of this. The candidates will at once undertake research, either in Inorganic, Organic, or Physical Chemistry, under the supervision of one of the instructors or docents. The degree will be conferred only after presenting a thesis embodying the results of a satisfactory amount of work which must be a real contribution to knowledge, and after passing an examination on the general field of chemistry, as well as examinations on one or more secondary, but allied, subjects.

INDEPENDENT WORK.

Special opportunities to pursue entirely independent research work will be given to maturer students who have already obtained the doctor's degree. After completion of a sufficient amount of creditable work, and presentation of a thesis embodying the results obtained, such students may be admitted as *docents*, thereby receiving the right to lecture, give laboratory instruction, and supervise research work in the Chemical Department of the University. Students of this class, as well as others, intending to engage in independent research, are requested to make known their special requirements as early as possible, in order that the requisite materials, which are not always accessible in America, may be obtained without delay.

SPECIAL STUDENTS.

Special students, not candidates for a degree, will be received, and will be given every possible facility, but in every case they will be required to give evidence, satisfactory to the instructors in the different branches, that their previous training has been sufficient, both in latitude and amount, to enable them to derive full profit from the courses they propose to take.

SEMINAR WORK.

A Chemical Seminar will be held, usually bi-weekly, in which instructors and all advanced students will take part, and in which recent chemical work will be presented and discussed, and informal lectures given on various topics of interest to chemists.

PREREQUISITES.

A good reading knowledge of French and German is desirable for Courses 9–17, and will be required for Courses 18–42.

Candidates for the degree of Doctor of Philosophy must have taken the first course in General Physics, and they are strongly advised to take the second course in Experimental Physics, which calls for the calculus as a prerequisite. They must also take courses in Crystallography and Mineralogy.

FELLOWSHIPS.

University fellowships yielding an income of $320 or $520 annually are open to graduate students in chemistry. The appointments to these fellowships will be based exclusively on merit. A fellow will be expected to render assistance to the Department in serving as an assistant at lectures or in the laboratory. In no case, however, will he be required, or allowed, to devote more than one-sixth of his time to such service.

PUBLICATIONS.

The scientific work carried out in the laboratory will be published in various existing periodicals as "Contributions from the Kent Chemical Laboratory of the University of Chicago." Owing to the fact that a journal devoted to pure scientific work in chemistry already exists in the country, it is deemed unnecessary to edit a departmental journal, but it is likely that the dissertations for a doctor's degree, carried out in the Department, may be published from time to time in the form of "Studies from the Kent Chemical Laboratory."

LIBRARY FACILITIES.

The Department is equipped with an almost complete list of periodicals, past and current, necessary for prosecuting research ; it also possesses a large number of reference and handbooks.

The following periodicals are received by the Department:

> American Chemical Journal; Journal of the Chemical Society (London); Chemical News; Berichte der Deutschen Chemischen Gesellschaft; Liebig's Annalen; Zeitschrift für Analytische Chemie; Zeitschrift für Anorganische Chemie; Zeitschrift für Physikalische Chemie; Journal of the American Chemical Society; Journal of Physical Chemistry; Journal für Praktische Chemie; Monatshefte für Chemie; Chemiker-Zeitung; Chemisches Centralblatt; Zeitschrift für Elektrochemie; Jahrbuch der Chemie; Jahresbericht über die Fortschritte der Chemie; Annales de Chimie et de Physique; Bulletin de la Société chimique de Paris; Recueil des Travaux chimiques des Pays-Bas; Gazetta Chimica Italiana.

A number of general scientific journals and many of the proceedings of learned societies are received in the General Library.

COURSES OF INSTRUCTION.

M=Minor course=a single course for six weeks. DM=Double Minor course=a double course (two hours daily) for six weeks. Mj=Major course=a single course for twelve weeks. DMj=Double Major course=double course for twelve weeks.

PRIMARILY FOR THE JUNIOR COLLEGES.

1, 2, 3. **General Inorganic Chemistry**; *Elementary Course.* — Autumn, Winter, and Spring Quarters, class room 3 hrs. a week, 12:00; laboratory 6 hrs. a week, 2:00–5:00. 3Mj.

ASSOCIATE PROFESSOR SMITH.

This is a continuous course through three Quarters.

The lectures and class-room work of 1, 2, and 3 may be taken by Graduate Students without the laboratory work or laboratory fee.

4. **General Inorganic Chemistry.**—Summer Quarter, '99, lectures 6 hrs. a week, 11:00; laboratory work 12 hrs. a week, 2:00–5:00. DMj.

ASSISTANT PROFESSOR LENGFELD.

The lectures and class-room work of 4 may be taken as a Major by Graduate Students without the laboratory work or laboratory fee.

General Chemistry.—Chiefly laboratory work.

Mj. Autumn Quarter, '99.

ASSOCIATE PROFESSOR SMITH.

Sequel to Course 4 and, with it, equivalent to Courses 1, 2, 3.

Courses 1 and 4 must be preceded by Preparatory entrance) Physics or its equivalent, including some laboratory work.

The aim of the equivalent continuous Courses 1, 2, 3; and 4, 5 will be to give a definite idea of the fundamental principles of chemistry, and not to overburden the student with a mass of unconnected facts. The lectures will be experimental to a considerable extent. A knowledge of the characteristic properties of the more common elements and their compounds will be acquired. The course is designed to meet the wants not only of those who wish to go deeper into chemistry, but of all who wish to secure a liberal education.

1B, 2B. **General Inorganic Chemistry**; *Special Course.* — Autumn and Winter Quarters, '99–1900, class room 3 hrs. a week, 12:00; laboratory 6 hrs. a week, 2:00–5:00. 2Mj.

ASSOCIATE PROFESSOR SMITH.

Prerequisite: *Entrance Chemistry and Physics, 1 unit each.*

1B and 2B, preceded by 1 unit entrance chemistry, are equivalent to the above continuous 3Mj courses. This is a special course designed to form a sequel to high-school chemistry. The laboratory and recitation work are distinct from that of Courses 1 and 2. Those registered for 1B and 2B are required to attend the lectures given to members of 1 and 2, at 12:00. Whenever the preparation justifies it, qualitative analysis (Course 6) may be substituted for 2B.

NOTE. — Two hours of laboratory are reckoned as equal to one hour of lecture work.

PRIMARILY FOR THE SENIOR COLLEGES.

6, 7. **Qualitative Analysis.**—Chiefly laboratory work. The instructor may at any time substitute one hour of class-room work for two hours of laboratory work.

2 Mj. or 2DM. 8 or 16 hrs. a week laboratory. 2 hrs. a week class room.

Autumn, Winter, and Spring Quarters, and First Term of Summer Quarter, '99.

Lectures: 2:00.

ASSISTANT PROFESSOR STIEGLITZ.

DR. JONES or DR. MCCOY assisting in the Laboratory.

Second Term of Summer Quarter, '99.

DR. JONES.

Prerequisite: *Courses 1, 2, 3,* or *4 and 5,* or *1B and 2B.*

Courses 6, 7, 8 form a continuous course, which may be begun in any quarter.

The aim in Courses 6, 7, 8 will be to train the student to do intelligent analytical work and to enable him to analyze, at the end of the course, without the use of a book or table, any mixture containing common inorganic compounds.

9, 10. **Quantitative Analysis.** — Chiefly laboratory work in volumetric and gravimetric analysis.

2Mj or 2DM. 10 or 20 hrs. a week.

Autumn, Winter, and Spring Quarters, '99–1900, and First Term of Summer Quarter, '99.

ASSISTANT PROFESSOR STIEGLITZ.

DR. JONES or DR. MCCOY assisting in the Laboratory.

Second Term, Summer Quarter, '99.

DR. JONES.

Prerequisite: *Qualitative Analysis.*

Courses 9, 10, 11 form a continuous course, which may be begun in any quarter.

PRIMARILY FOR THE GRADUATE SCHOOL.

8. **Advanced Qualitative Analysis.**—Mj or DM. 8 or 16 hrs. a week, laboratory; 2 hrs. a week class room.

Autumn, Winter, and Spring Quarters, '99–1900, and First Term of Summer Quarter, '99.
ASSISTANT PROFESSOR STIEGLITZ.
Second Term of Summer Quarter, '99.
DR. JONES.

Open to College students. Continuation of Courses 6 and 7.

11. **Advanced Quantitative Analysis.** — Mj or DM 10 or 20 hrs. a week.

Autumn, Winter, and Spring Quarters, '99–1900, and First Term of Summer Quarter, '99.
ASSISTANT PROFESSOR STIEGLITZ.
Second Term of Summer Quarter, '99
DR. JONES.

Continuation of Courses 9 and 10. Open to students in the Senior Colleges.

12. **Elementary Spectrum Analysis (Qualitative).** — Emission (flame and electric spark) and absorption spectra of inorganic substances. Chiefly laboratory work.

½Mj. Winter Quarter, 1900.
DR. JONES.

13. **Special Methods in Quantitative Analysis.**—Special analysis of water, ores, minerals, etc.; gas analysis; analysis by electrolytic methods Chiefly laboratory work.

Autumn and Winter Quarters, and First Term of Summer Quarter.
ASSISTANT PROFESSOR STIEGLITZ.

Prerequisite: *Quantitative Analysis.*

Candidates for the degree of Ph.D. intending to pursue research work in Inorganic Chemistry will be required to take 2DM or 2Mj of this course; those intending to pursue research work in Organic Chemistry will be required to take one DM or Mj.

14, 15, 16. **Organic Chemistry.**—The compounds of carbon, including the fatty and the aromatic series. The aim of the course will be to take up very thoroughly the simpler compounds, going with great detail into the chemical behavior, the characteristic reactions and relationships of the different classes of organic compounds, and considering the synthetic methods by which they can be obtained, with great care. Richter's or Bernthsen's *Organic Chemistry* is used as a reference book, but recent literature will, in special cases, be considered in detail. Lectures. 5M. Autumn and Winter Quarters, and First Term of Spring Quarter; 12:00.
PROFESSOR NEF.

Prerequisite: *General Chemistry and Qualitative Analysis.*

17. **General Organic Chemistry.**—Fatty and aromatic series.

Lectures, 5 hrs. a week. Mj.
Summer Quarter, '99; 8:30.
DR. JONES.

Prerequisite: *General Chemistry and Qualitative Analysis.*

18, 19, 20. **Organic Preparations.** — Laboratory work, 10 or 20 hrs. a week. M or DM.

Autumn and Winter Quarters, and First Term of Spring Quarter.
Second Term of Summer Quarter, '99.
PROFESSOR NEF.
Second Term, Spring Quarter, 1900.
ASSOCIATE PROFESSOR SMITH.

Prerequisite: *Qualitative and Quantitative Analysis*, *Mineralogy* (for candidates for the degree of Ph.D.), and *Organic Chemistry* (it may be taken simultaneously in connection with lectures on Organic Chemistry). Those intending to pursue research work in Inorganic Chemistry will be required to take 2DM of this course and those intending to pursue research work in Organic Chemistry will be required to take the 3DM. A reading knowledge of French and German is essential.

21, 22. **Organic Preparations.**—Laboratory work; 10 or 20 hrs. a week. M or DM.

First Term, Summer Quarter, '99.
DR. JONES.

Prerequisite: *As in Course 18.*

23. **Advanced General Chemistry.** — Causes of and conditions for chemical action. 4 hrs. a week.

Mj. Spring Quarter; 8:30.
ASSOCIATE PROFESSOR SMITH.

Prerequisite: *College Physics*, *General Chemistry, and Qualitative Analysis.*

24. **Advanced Inorganic Chemistry.**—Two lectures a week on selected topics. ½Mj.

Autumn Quarter.
ASSISTANT PROFESSOR LENGFELD.

Prerequisite: *General Chemistry and Qualitative Analysis.*

25, 26, 27. **Inorganic Preparations.**—Laboratory work, 2 or 3DM, or 2 or 3Mj. 10 or 20 hrs. a week.

Summer and Autumn Quarters, and First Term of Winter Quarter, '99–1900.

ASSISTANT PROFESSOR LENGFELD.

Prerequisite: *Qualitative and Quantitative Analysis, and a reading knowledge of French and German.*

Those intending to pursue research work in Organic Chemistry will be required to take 2DM of this course; those intending to engage in Inorganic Research will be required to take 3DM.

31, 32. **Theoretical Chemistry.**—With special reference to physical methods. 2 hrs. a week, Autumn Quarter; 4 hrs. a week, First Term of Winter Quarter.

4M. Autumn Quarter and First Term of Winter Quarter; 8:30.

ASSISTANT PROFESSOR LENGFELD.

Prerequisite: *College Physics and General Chemistry.*

33. **Research Work for Ph.D. Thesis.**—This course will include from 30 to 40 hrs. a week of laboratory work, under the special direction of some one of the instructors in the department. It is expected that a student will be occupied for a period of 4–8 quarters, 4–8 DMj.

33*a*. RESEARCH IN ORGANIC CHEMISTRY.—Second Term of Summer Quarter, Autumn and Winter Quarters, and First Term of Spring Quarter.

PROFESSOR NEF.

33*b*. RESEARCH IN GENERAL CHEMISTRY. — Autumn, Winter, and Spring Quarters.

ASSOCIATE PROFESSOR SMITH.

33*c*. RESEARCH IN INORGANIC CHEMISTRY. — Summer, Autumn, and First Term of Winter Quarters.

ASSISTANT PROFESSOR LENGFELD.

33*d*. RESEARCH IN ORGANIC CHEMISTRY. — Autumn, Winter, and Spring Quarters, and First Term of Summer Quarter.

ASSISTANT PROFESSOR STIEGLITZ.

Before being admitted to Research, a candidate must satisfy the instructors of the department, by an oral test, or otherwise, that his or her previous training has been sufficient.

A candidate for the degree of Ph.D. must have taken Courses 1, 2, 3 (or 4, 5), (or 1*B*, 2*B*) 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 31, 32; the amount required of courses 18, 19, 20 and 25, 26, 27; as well as at least eight ½Mj among the special Courses 12, 23, 24, 34, 35, 36, 37, 38, 39, 40, 41 42, or their equivalent.

34. **Physico-Chemical Methods.** — Determination of specific gravity, molecular weights, etc. Laboratory work, 5 hrs. a week.

M. First Term of Winter Quarter.

ASSISTANT PROFESSOR LENGFELD.

35. **The Carbohydrates and Complex Hydrocarbons** (including the terpenes), and their derivatives.

Lectures, 2 hrs. a week. ½Mj. Autumn Quarter, 1900.

ASSISTANT PROFESSOR STIEGLITZ.

Prerequisite: *Organic Chemistry.*

36. **Organic Nitrogen Derivatives.**—Uric acid series; pyridine, quinone-imides, and phenazine compounds; a discussion of the alkaloids, ptomaines, and organic dye-stuffs.

Lectures, 2 hrs. a week.

½Mj. Winter Quarter, 1901.

ASSISTANT PROFESSOR STIEGLITZ.

Prerequisite: *Organic Chemistry.*

37. **Special Chapters of Organic Chemistry.** — Lectures, 4 hrs. a week.

M. Second Term, Summer Quarter, '99; 12:00.

PROFESSOR NEF.

Prerequisite: *Organic Chemistry.*

38, 39. **The Aromatic Series.** — Lectures, 2 hrs. a week.

2M. Winter and Spring Quarters, 1900.

ASSISTANT PROFESSOR STIEGLITZ.

Prerequisite: *Organic Chemistry.*

42. **History of Chemistry.** — 2 hrs. a week. Winter and Spring Quarters. Two ½Mj.

[Not to be given in '99–1900.]

43. **Journal Meetings.**

Autumn and Winter Quarters.

PROFESSOR NEF.

All candidates for the degree of Ph.D., more advanced students, docents, and instructor will be present, and take part in turn in presenting and discussing recent investigations. Meetings will be held on alternate Fridays from 5:00 to 6:00. They may be attended by anyone interested, whether connected with the University or not; the subjects for the meetings will be announced at least one week beforehand.

CONSPECTUS OF COURSES.

CHEMISTRY.

NOTE.—Laboratory Fees are due in addition to the Tuition Fees for all laboratory courses in the Department of Chemistry, as follows: Minor courses, $2.50; Major or Double Minor Courses, $5.00; Double Majors, $10.00.

SUMMER	*AUTUMN*	*WINTER*	*SPRING*
JUNIOR COLLEGE COURSES			
4 General Chemistry DMj Lectures: **Mon.–Sat. 11:00 𝕶 20** Laboratory: (after one week) **Mon.–Thurs. 2:00–5:00** (*Lengfeld*) **𝕶 36** The lectures of Course 4 may be taken by graduate students as a Major without the laboratory work or laboratory fee.	1 Elementary General Chemistry,[1] continued in Winter and Spring Quarters Mj **Mon.–Wed. 12:00 𝕶 20** Laboratory: **Thurs. & Fri. 2:00–5:00** (*Smith*) **𝕶 37** The lectures of Course 1 may be taken by graduate students as a ½Mj without the laboratory work or laboratory fee Students having credit for entrance Chemistry, take 1B	2 Elementary General Chemistry[1] Second Quarter Mj **Mon.–Wed. 12:00 𝕶 20** Laboratory: **Thurs. & Fri. 2:00–5:00** (*Smith*) **𝕶 37** The lectures of Course 2 may be taken by graduate students without the laboratory work or laboratory fee	3 Elementary General Chemistry Third Quarter Mj **Mon.–Wed. 12:00 𝕶 20** **Thurs. & Fri. 2:00–5:00** (*Smith*) **𝕶 37** The lectures of Course 3 may be taken by graduate students without the laboratory work or laboratory fee
	1B General Chemistry, advanced course, concluded in Winter Quarter Mj **Mon.–Wed. 12:00 𝕶 20** Laboratory: **Thurs. & Fri. 2:00–5:00** (*Smith*) **𝕶 36**	2B General Chemistry, advanced course, sequel to 1B Mj **Mon.–Wed. 12:00** Laboratory: **Thurs. & Fri. 2:00–5:00** (*Smith*) **𝕶 36**	
	5 General Chemistry Mj (*Smith*) **𝕶 20** (Sequel to Course 4)		
SENIOR COLLEGE COURSES			
†6, 7 Qualitative Analysis M or DM Lectures: **𝕶 20** **Mon. and Thurs. 2:00** First Term (*Stieglitz*) Second Term (*Jones*) **𝕶 24**	†6, 7 Qualitative Analysis Mj or DM Lectures: **𝕶 20** **Mon. and Thurs. 2:00** (*Stieglitz*) **𝕶 24** Prerequisite: XX-3 or 4 or 5A	†6, 7 Qualitative Analysis Mj or DM Lectures: **𝕶 20** **Mon. and Thurs. 2:00** Laboratory: **𝕶 24** (*Stieglitz*) Prerequisite: XX-2B or 3 or 4	†6, 7 Qualitative Analysis Mj or DM Lectures: **𝕶 20** **Mon. and Thurs. 2:00** Laboratory: **𝕶 24** (*Stieglitz*) Prerequisite: XX-2B or 3 or 4
†9, 10 Quantitative Analysis M or DM First Term (*Stieglitz*) Second Term (*Jones*) **𝕶 24**	†9, 10 Quantitative Analysis Mj or DM (*Stieglitz*) **𝕶 24** Prerequisite: XX-7 or 8	†9, 10 Quantitative Analysis Mj or DM (*Stieglitz*) **𝕶 24** Prerequisite: XX-7 or 8	†9, 10 Quantitative Analysis Mj or DM (*Stieglitz*) **𝕶 24** Prerequisite: XX-7 or 8

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[1] Courses 1 and 2, or Course 4, are required of students in the College of Science who did not receive credit for Chemistry on admission.

† Courses 6, 7, and 8 constitute three quarters' work and may be begun any quarter. The student registering for his first quarter's work in Qualitative Analysis registers for 6; for his second quarter's work, for 7; for his third quarter's work, for 8. Any one of these courses may be taken as a Mj or as a DM. The same arrangement holds for Courses 9, 10, and 11.

CHEMISTRY.—(*Continued.*)

SUMMER	*AUTUMN*	*WINTER*	*SPRING*
GRADUATE COURSES			
8 Advanced Qualitative Analysis M or DM First Term (*Stieglitz*) Second Term (*Jones*) Ꝁ 24	8 Advanced Qualitative Analysis Mj or DM (*Stieglitz*) Ꝁ 24	8 Advanced Qualitative Analysis Mj or DM (*Stieglitz*) Ꝁ 24 Prerequisite: XX-7	8 Advanced Qualitative Analysis Mj or DM (*Stieglitz*) Prerequisite: XX-7
11 Advanced Quantitative Analysis M or DM First Term (*Stieglitz*) Second Term (*Jones*) Ꝁ 24	11 Advanced Quantitative Analysis Mj or DM (*Stieglitz*) Ꝁ 24	11 Advanced Quantitative Analysis Mj or DM (*Stieglitz*) Ꝁ 24 Prerequisite: XX-10	11 Advanced Quantitative Analysis Mj or DM (*Stieglitz*) Prerequisite: XX-10
		12 Elementary Spectrum Analysis ½Mj (*Jones*) Ꝁ 44	16 Organic Chemistry M First Term Thurs.–Sat. 12:00 (*Nef*) Ꝁ 22
13 Special Methods in Quantitative Analysis M or DM First Term (*Stieglitz*) Ꝁ 24	13 Special Methods in Quantitative Analysis Mj or DMj (*Stieglitz*) Ꝁ 24	13 Special Methods in Quantitative Analysis Mj or DM (*Stieglitz*) Ꝁ 24	†18, 19, 20 Organic Preparations M or DM First Term (*Nef*) Ꝁ 21
17 Organic Chemistry Mj Mon.–Fri. 8:30 (*Jones*) Ꝁ 22	14 Organic Chemistry Mj Thurs.–Sat. 12:00 (*Nef*) Ꝁ 22	15 Organic Chemistry Mj Thurs.–Sat. 12:00 (*Nef*) Ꝁ 22	
18, 19, 20 Organic Preparations DM or M Second Term (*Nef*) Ꝁ 21	†18, 19, 20 Organic Preparations Mj or DM (*Nef*) Ꝁ 21	†18, 19, 20 Organic Preparations Mj or DM (*Nef*) Ꝁ 21	†18, 19, 20 Organic Preparations M or DM Second Term (*Smith*) Ꝁ 21
†21, 22 Organic Preparations DM or M First Term (*Jones*) Ꝁ 21	24 Advanced Inorganic Chemistry ½Mj (*Lengfeld*) Ꝁ 22	†25, 26, 27 Inorganic Preparations M or DM First Term (*Lengfeld*) Ꝁ 21 Prerequisite: XX-7, 10	23 Advanced General Chemistry Mj Mon.–Thurs. 8:30 (*Smith*) Ꝁ 20
†25, 26, 27 Inorganic Preparations Mj or DM (*Lengfeld*) Ꝁ 21	†25, 26, 27 Inorganic Preparations Mj or DM (*Lengfeld*) Ꝁ 21		†25, 26, 27 Inorganic Preparations Mj or DM (*Smith*) Ꝁ 21 Prerequisite: XX-7, 10
	31 Theoretical Chemistry ½Mj Tues. and Fri. 8:30 (*Lengfeld*) Ꝁ 22	32 Theoretical Chemistry M First Term Tues., Wed., Fri. & Sat. 8:30 (*Lengfeld*) Prerequisite: XX-31	
33*a* Research DM Second Term (*Nef*) Ꝁ 31	33*a* Research DMj (*Nef*) Ꝁ 31	33*a* Research DMj (*Nef*) Ꝁ 31	33*a* Research DM First Term (*Nef*) Ꝁ 31
	33*b* Research DMj (*Smith*) Ꝁ 31	33*b* Research DMj (*Smith*) Ꝁ 31	33*b* Research DMj (*Smith*) Ꝁ 31
33*c* Research DMj (*Lengfeld*) Ꝁ 31	33*c* Research DMj (*Lengfeld*) Ꝁ 31	33*c* Research DM First Term (*Lengfeld*) Ꝁ 31	
33*d* Research DM First Term (*Stieglitz*) Ꝁ 31	33*d* Research DMj (*Stieglitz*) Ꝁ 31	33*d* Research DMj (*Stieglitz*) Ꝁ 31	33*d* Research DMj (*Stieglitz*) Ꝁ 31
37 Special Chapters of Organic Chemistry M Second Term Wed.–Sat. 12:00 (*Nef*)		34 Physico-Chemical Methods M First Term (*Lengfeld*) Prerequisite: XX-31	
		38 The Aromatic Series ½Mj Mon. and Thurs. 8:30 (*Stieglitz*) Ꝁ 22	39 The Aromatic Series ½Mj Mon. and Thurs. 8:30 (*Stieglitz*) Ꝁ 22
	43 Journal Meeting Fri. 5:00 (*Nef*)	43 Journal Meeting Fri. 5:00 (*Nef*) Ꝁ 22	

†Courses 18, 19, and 20 constitute three quarters' work, and may be begun any quarter. The student registering for his first quarter's work in Organic Preparations registers for 18; for his second quarter's work, for 19; for his third quarter's work, for 20. Any one of these courses may be taken as a Mj or as a DM. The same principles apply to 25, 26, and 27.

THE KENT CHEMICAL LABORATORY.

OFFICERS OF GOVERNMENT.

JOHN ULRIC NEF, *Professor of Chemistry and Director.*
ALEXANDER SMITH, *Associate Professor of General Chemistry.*
FELIX LENGFELD, *Assistant Professor of Inorganic Chemistry.*
JULIUS STIEGLITZ, *Assistant Professor of Chemistry.*
MASSUO IKUTA, *Instructor in Chemistry.*
LAUDER W. JONES, *Assistant in Chemistry.*
JAMES H. RANSOM, *Lecture Assistant.*
HERBERT N. McCOY, *Laboratory Assistant.*

THE BUILDING.

The Chemical Laboratory, provided by the generosity of Mr. Sidney A. Kent, was opened January 1, 1894.

The rooms are arranged as follows:

The *basement* contains a furnace room, with a set of gas furnaces, with air blast of the most modern construction, for crucible work, muffle work, tube heating, and other purposes; a constant temperature room, a room fitted with steam and other appliances for work on a large scale, a mechanical workshop, and storage rooms.

On the *first floor* are one small and two large lecture rooms, and a large lecture hall seating three hundred persons, fitted for use as a chemical lecture room, if desired. This floor also contains a chemical museum, a large private laboratory, a room with northern exposure, especially fitted for use as a gas analysis laboratory, and also apparatus and preparation rooms connected with the lecture rooms.

On the *second floor* are two large laboratories intended for research and advanced work, three private laboratories for the professors, balance, combustion. air furnace, and storerooms, a balcony for out-of-door work, and the chemical library, which contains full sets of the most important journals, as well as the most important text-books and other works, relating to chemistry.

On the *third floor* are three large laboratories for general and analytical chemistry, a storeroom, a preparation room, a room especially fitted for optical and photographic work, a balance room, and a private laboratory. The most modern system of ventilation has been adopted, air of constant temperature being forced in by fans from below, and withdrawn by a fan above. The building will be lighted throughout by electric lights, and the laboratories will be provided with electricity adapted to every kind of electro-chemical work.

The fullest opportunity will be given for doing research work. All possible aid will be afforded those who desire to avail themselves of the facilities of the laboratory.

The Officers of the Department of Chemistry will be glad to answer inquiries from institutions looking for well-equipped teachers of Chemistry.

Letters of inquiry and requests for documents should be addressed to

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The Biblical World	Edited by President W. R. Harper. Monthly; about 80 pages, with special numbers in June and December. A popular monthly magazine; illustrated; devoted exclusively to biblical study. The best magazine published for the busy minister, the Sunday-school teacher, and the thinking layman.	$2.00 a year Foreign: $2.50 Single copies 20 cents
The School Review	Edited by Charles H. Thurber. Monthly, except in July and August; averages about 80 pages. This publication is distinctively the national representative of high-school and academic work. It is the only magazine devoted exclusively to secondary education.	$1.50 a year Foreign: $2.00 Single copies 20 cents
The American Journal of Sociology	Edited by Albion W. Small. Bimonthly. This journal is the result of the increased popular interest in social questions. It presents to its readers issue by issue the latest developments in sociological thought and in social endeavor.	$2.00 a year Foreign: $2.50 Single copies 35 cents
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PROGRAMME OF THE DEPARTMENTS OF
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1901-1902

CHICAGO
The University of Chicago Press
1901

CONSPECTUS OF COURSES, 1901–1902

MATHEMATICS

SUMMER	AUTUMN	WINTER	SPRING
1 Trigonometry (*Young*) 2 College Algebra (*Boyd*) 2*A* Surveying and Navigation (*Dickson*) 3 Analytic Geometry (*Slaught*)	0*a* Solid Geometry (*Young*) 0*b* Solid Geometry. (———) 1*a* Trigonometry (*Young, Boyd, Slaught*) 1*b* Trigonometry (*Boyd, ———, Young*) 3 Analytic Geometry (*Boyd*)	1*a* Trigonometry (*Boyd, Dickson*) 1*b* Trigonometry (*Dickson, Boyd*) 2*a* College Algebra (*Boyd, Slaught, Young*) 2*b* College Algebra (*Young, Dickson*)	1 Trigonometry (———) 2*a* College Algebra (*Dickson*) 2*b* College Algebra (———) 2*A* Surveying and Navigation (*Dickson*) 3 Analytic Geometry (*Slaught*) 4 Calculus (*Young*)
12 Differential Calculus (*Young*) 14 Integral Calculus (*Veblen*) 16 Solid Analytics and Determinants (*Boyd*) 27 Differential Equations (*Slaught*)	11 Calculus I (*Moore*) 17 Advanced Algebra I (*Bolza*) 23 Advanced Integral Calculus I (*Slaught*) [ASTRONOMY 5.] Analytic Mechanics I (*Laves*)	13 Calculus II (*Moore*) 19 Advanced Algebra II (*Bolza*) 25 Advanced Integral Calculus II (*Slaught*) [ASTRONOMY 6.] Analytic Mechanics II (*Laves*)	15 Calculus III (*Moore*) 21 Solid Analytics (*Young*) 27 Advanced Integral Calculus III (*Slaught*)
30 Conferences on the Pedagogy of Mathematics (*Young*) 35*B* Mathematical Reading (*Bolza*) 40 Calculus of Variations (*Bolza*) 45*A* Pure Projective Geometry 1T (*Dickson*) 45*B* Analytic Projective Geometry 2T (*Dickson*) 51 Theory of Functions of a Complex Variable (*Bolza*) 56 Hyperelliptic Functions (*McDonald*)	35*A B C* Mathematical Reading (*Moore, Bolza, Maschke*) 52 Theory of Functions I (*Maschke*) 50 Theory of Invariants (*Maschke*) 57 Abelian Functions (*Bolza*) 53 Theory of Functions of Real Variables (*Moore*)	35*A B C* Mathematical Reading (*Moore, Bolza, Maschke*) 52*A* Theory of Functions II (*Maschke*) 44 Twisted Curves and Surfaces (*Maschke*) 73 Seminar B (*Bolza*) 70 Seminar A I (*Moore*)	35*A B C* Mathematical Reading (*Moore, Maschke*) 52*B* Theory of the Potential (*Maschke*) 76 Seminar C (*Maschke*) 61 Theory of Numbers (*Dickson*) 71 Seminar A II (*Moore*)

XVII. THE DEPARTMENT OF MATHEMATICS.

OFFICERS OF INSTRUCTION.

ELIAKIM HASTINGS MOORE, Ph.D., *Professor and Head of the Department of Mathematics.*

OSKAR BOLZA, Ph.D., *Professor of Mathematics.*

HEINRICH MASCHKE, Ph.D., *Associate Professor of Mathematics.*

WILLIAM HOOVER, Ph.D., *Non-Resident University Extension Assistant Professor of Mathematics.*

HERBERT ELLSWORTH SLAUGHT, Ph.D., *Assistant Professor of Collegiate Mathematics; Departmental Examiner.*

JACOB WILLIAM ALBERT YOUNG, Ph.D., *Assistant Professor of the Pedagogy of Mathematics.*

LEONARD EUGENE DICKSON, Ph.D., *Assistant Professor of Mathematics.*

JAMES HARRINGTON BOYD, Sc.D., *Instructor in Mathematics.*

JOHN HECTOR McDONALD, A.B., Ph.D., *Instructor in Mathematics, Burlington Institute* (Summer Quarter, 1901).

FELLOWS.

1901-1902.

WILLIAM JAMES RUSK, A.M.

ARTHUR RICHARD SCHWEITZER, Ph.B.

ARTHUR WHIPPLE SMITH, S.B.

OSWALD VEBLEN, A.M.

THE SCHEME OF THE COURSES OF INSTRUCTION.

COLLEGIATE ENTRANCE REQUIREMENTS.

1. *Algebra*—through radicals, exponents, imaginaries, and theory of quadratic equations. (Special attention should be given to the solution of equations and to miscellaneous problems involving equations.)
2. *Plane Geometry.* } (The demonstration of original propositions and the solution of original problems will
3. *Solid Geometry.* } be required.)

Algebra and *Plane Geometry* are prescribed entrance requirements; *Solid Geometry* is an elective entrance requirement.

COURSES IN ELEMENTARY MATHEMATICS.

Course 0, *Solid Geometry* (Autumn Quarter) is to be taken by those students entering without solid geometry.

The regular Junior College courses are: Course 1, *Trigonometry;* Course 2, *College Algebra,* including the elementary theory of finite and infinite algebraic and trigonometric series; Course 2A, *Surveying and Navigation;* Course 3, *Analytic Geometry;* Course 4, *Calculus* (shorter course); and Courses 11, 13, 15, *Calculus* (longer course). The arrangement of sections for the year 1901–2 is given below. In their first year of residence Junior College students of the College of Science are required to take Courses 1, 2, 3; other Junior College students are required to take Courses 1, 2. Course 2A may however be substituted for Course 2, and Course 4 for Course 3. The required work in Mathematics should be taken as soon after entrance as possible.

Students who expect to specialize in Mathematics, Astronomy, Physics, or Chemistry should take Courses 1, 2, 3, 11, 13, 15. Students who expect to specialize in other sciences, or who desire to have at least a glimpse beyond the elements of Mathematics, should elect Courses 3 and 4, or Course 3, or Course 4.

INITIAL COURSES IN THE HIGHER MATHEMATICS.

The following courses introductory to the higher Mathematics are intended for students making Mathematics their principal subject, and partly also for those making Mathematics their secondary subject, in particular for students of Astronomy and Physics:

(*A*) †*Differential and integral calculus* (*3Mjs*).

(*B*) † *Theory of equations, including determinants* (*2Mjs*); *solid analytics.*

(*C*) † *Advanced integral calculus, including definite integrals, Fourier series, elements of elliptic integrals and functions, differential equations* (*3Mjs*).

(*D*) †*Analytic mechanics* (*2Mjs.*); *theoretical mechanics.*

(*E*) *Projective geometry; modern analytic geometry; differential geometry* (*2Mjs*).

(*F*) †*Elements of the theory of functions* (*2Mjs*); *calculus of variations; theory of the potential; elliptic functions; linear differential equations.*

(*G*) *Theory of numbers; theory of invariants; selected chapters of algebra; theory of substitutions with applications to algebraic equations; quaternions.*

The groups (*A*)–(*G*) indicate the permanent constituents of seven sequences of courses running through the usual academic year from October to June. These sequences vary slightly from year to year, the courses marked with a dagger (†) being given annually, and the other courses being given usually once in two years. Special emphasis will be laid upon the application of calculus to the solution of analytical, geometrical, and mechanical problems.

The undergraduate student who wishes to specialize in Mathematics should take (*A*) as Junior College Elective, (*B*) in his first, (*C*) and (*D*) in his second Senior College year.

Candidates for the Master's degree with Mathematics as principal subject are expected to offer for examination the subjects covered by the courses of groups (*A*)–(*D*), and three Majors selected from (*E*)–(*G*), or the equivalents of these subjects, and to present a satisfactory thesis on an assigned topic closely related to one of these subjects.

Candidates for the Doctor's degree with Mathematics as secondary subject are expected to offer for examination the subjects covered by the courses of groups (*A*)–(*D*), and one Major selected from (*E*)–(*G*), or the equivalents of these subjects.

SPECIAL COURSES IN THE HIGHER MATHEMATICS.

The science of Mathematics embraces the four highly related but independent sciences: Algebra and Arithmetic, Analysis, Geometry, and Mechanics.

The department offers the following courses in the higher Mathematics:

Algebra and Arithmetic.—Initial courses in groups (*B*) and (*G*), and special courses as follows: *Linear substitution groups; congruence groups; abstract groups; algebraic numbers; general arithmetic; and research Seminars.*

Analysis.—Initial courses in groups (*A*), (*C*), and (*F*), and special courses as follows: *Theory of functions of real and of complex variables; Lie's theory of differential equations; continuous groups; elliptic functions; hyperelliptic functions; abelian functions; elliptic modular functions; and research Seminars.*

Geometry.—Initial courses in groups (*B*) and (*E*), and special courses as follows: *Differential geometry; higher plane curves; algebraic surfaces; Lie's theory of differential equations; continuous groups; linear substitution groups; and research Seminars.*

Mechanics.—Initial courses in groups (*D*) and (*F*). Special courses in Mechanics, and especially in Celestial Mechanics, are offered by the Department of Astronomy, and in Theoretical Physics by the Department of Physics.

The initial and special courses in the higher Mathematics are intended to give the graduate student a comprehensive view of modern Mathematics, to develop him to scientific maturity, and to enable him to follow, without further guidance, the scientific movement of the day, and, if possible, to take an active part in it by creative research. The special courses and research Seminars vary from year to year.

Candidates for the Doctor's degree with Mathematics as principal subject are expected to present a dissertation, in finished form, embodying valuable results of mathematical inquiry, and to offer for examination the subjects covered by the initial courses of groups (*A*)–(*G*), and by a considerable body of special courses, in each case presumably most closely related to the subject of the candidate's dissertation.

GENERAL STATEMENT TO STUDENTS OF MATHEMATICS.

Students of Mathematics should understand that the proper arrangement of their course of study in Mathematics is a matter of extreme importance. The best arrangement for a particular student is apt to depend on his previous mathematical career, and can be determined often only by conference between the student and a member of the staff of the department. The members of the staff are at all times ready to arrange for such conferences.

THE SUMMER QUARTER.

The courses of the Summer Quarter are designed to meet the needs of those college men and others wishing to study advanced Mathematics, who are able to spend only the summer in residence. The courses of a series of four summer quarters will be arranged so as to give a wide view of modern Mathematics; every summer there is given a course on the Pedagogy of Mathematics.

The attention of any student wishing the guidance of the department in his continuation of the work done in the summer is called to the correspondence courses of the department given under the auspices of the University Extension Division of the University.

FELLOWSHIPS IN MATHEMATICS.

To students in Mathematics are usually assigned three or four Fellowships. These Fellowships are assigned to those students excelling in their mathematical acquisitions and scholarly abilities who exhibit strongest evidences of marked creative ability in Mathematics. It is a distinct advantage to candidates to have been at least one year in residence at the University. Candidates should file with the President of the University (on application blanks to be secured from the President's Secretary) records of their previous work and distinctions, degrees, and past courses of study, with copies of their written or printed work in Mathematics. Applications should be filed before March 1 of each year. The appointments are made at the March Convocation of the University.

Fellows agree not to give private tuition, and may be called upon for assistance in any departmental teaching or other work; in no case, however, will a Fellow be expected or permitted to devote more than one sixth of his time to such service.

SCHOLARSHIPS IN MATHEMATICS.

Senior College Scholarship.—This Scholarship is awarded annually at the July Convocation to that student admitted to the Senior College during the preceding year who did the best Junior College work in Mathematics. In judging of the work of each candidate for this Scholarship the department considers (*a*) the general quality of his Junior College work; (*b*) the quantity and the quality of his Junior College work in Mathematics; (*c*) the results of the Senior College Scholarship Examination on the subjects: Trigonometry, College Algebra, and Analytic Geometry.

Graduate Scholarship.—This Scholarship is awarded annually at the July Convocation to that student admitted to the Ogden Graduate School during the preceding year who has been named by the department as the Senior College honor student in Mathematics. In judging of the work of each candidate for this Scholarship the department considers (*a*) the quantity and the quality of his Senior College work in Mathematics; (*b*) the results of the Graduate Scholarship Examination on the subjects: Differential and Integral Calculus, Advanced Algebra, Solid Analytics, and Advanced Integral Calculus; (*c*) his promise of success as a graduate student of Mathematics.

Scholarship Examinations.—The Senior College Scholarship Examination and the Graduate Scholarship Examination are held every Spring Quarter at times and places duly announced in the *University Record*. Prospective candidates should confer with the Departmental Examiner. Files of papers set at previous Scholarship Examinations are accessible in the Departmental Library.

MATERIAL FACILITIES OF THE DEPARTMENT.

Library.—The Mathematical Library occupies Room 37 of the Ryerson Physical Laboratory, adjacent to the lecture-rooms of the department, and is open for the use of graduate students from 8:30 A.M. to 6:00 P.M. The library contains the more important mathematical periodicals, collected works, treatises, and text-books.

Models.— A collection of Brill's models : Plaster and thread models of quadric surfaces, plaster models of cubic and Kummer's quartic surfaces, models of cyclides and surfaces of constant positive and negative curvature, and thread models of three-dimensional projections of four-dimensional regular bodies.

COURSES OF INSTRUCTION.

Summer Quarter, 1901—Spring Quarter, 1902.

M=Minor course=a single course for six weeks. DM=Double Minor course=a double course (two hours daily) for six weeks
Mj=Major course=a single course for twelve weeks. DMj=Double Major course=a double course for twelve weeks.

I. JUNIOR COLLEGE COURSES.

[NOTE.—Any student permitted to matriculate with entrance conditions in Mathematics is expected to remove these conditions at the next regular entrance examination, and, until this has been done, he may not begin his required college mathematics.]

0. **Solid Geometry.**

Mj. Autumn Quarter.
Sec. 0*a* ASSISTANT PROFESSOR YOUNG.
Sec. 0*b* MR. ———.

Required of all students who were not credited with Solid Geometry on admission.

1. **Trigonometry.**—Plane trigonometry, with an introduction to spherical trigonometry.

Mj. Summer Quarter.
ASSISTANT PROFESSOR YOUNG.

Mj. Autumn Quarter.
In two divisions of three graded sections each.

Div. 1*a* { ASSISTANT PROFESSOR YOUNG.
DR. BOYD.
ASSISTANT PROFESSOR SLAUGHT.

Div. 1*b* { DR. BOYD.
MR. ———.
ASSISTANT PROFESSOR YOUNG.

Mj. Winter Quarter.
In two divisions of two graded sections each.

Div. 1*a* { DR. BOYD.
ASSISTANT PROFESSOR DICKSON.

Div. 1*b* { ASSISTANT PROFESSOR DICKSON.
DR. BOYD.

Mj. Spring Quarter.
MR. ———.

Required of all students.

2. **College Algebra.**—The elementary theory of finite and infinite algebraic and trigonometric series.

Mj. Summer Quarter.
DR. BOYD.

Winter Quarter.
In two divisions of respectively three and two sections each.

Div. 2*a* { DR. BOYD.
ASSISTANT PROFESSOR SLAUGHT.
ASSISTANT PROFESSOR YOUNG.

Div. 2*b* { ASSISTANT PROFESSOR YOUNG.
ASSISTANT PROFESSOR DICKSON.

Spring Quarter.
Sec. 2*a* ASSISTANT PROFESSOR DICKSON.
Sec. 2*b* MR. ———.

Required of all students. (See Course 2A.)

2A. **Surveying and Navigation.**—This course includes practical work with surveying instruments.

Mj. Summer Quarter.
ASSISTANT PROFESSOR DICKSON.

Mj. Spring Quarter.
ASSISTANT PROFESSOR DICKSON.

Prerequisite : *Course 1.*

This course may be substituted for Course 2 as a required course. Course 2 is, however, a prerequisite for Course 3.

3. **Analytic Geometry.**—Elements of plane analytics, including the geometry of the conic sections, with an introduction to solid analytics.

Mj. Summer Quarter.
ASSISTANT PROFESSOR SLAUGHT.

Mj. Autumn Quarter.
DR. BOYD.

Mj. Spring Quarter
ASSISTANT PROFESSOR SLAUGHT.

Prerequisite : *Courses 1 and 2.*

Required of all students in the College of Science. (See Course 4.)

4. **Calculus** (shorter course).—The fundamental principles and the general methods will be carefully studied, and illustrated by simple applications arising in mathematics and the physical sciences.

Spring Quarter.
ASSISTANT PROFESSOR YOUNG.

Prerequisite : *Courses 1 and 2* (*Trigonometry and College Algebra*). *Course 3* (*Analytic Geometry*) *is desirable, but not indispensable.*

This course is intended for those who do not wish to take the longer course in Calculus (three quarters), but who, nevertheless, desire to round out their previous mathematical work with some knowledge of a subject of such great importance, both in pure mathematics and the natural sciences, as the Calculus. Certain students expecting to take the longer course in Calculus may advisably take this course as an introductory course.

Students of the College of Science may take Course 4 instead of Course 3 as a required course.

Junior College Elective. — The Courses 11, 13, 15; *Calculus* I, II, III, should be taken as Junior College Elective in their second year of residence by those students intending to make a special study of Mathematics, the required Courses 1, 2, 3 having been taken in their first year of residence.

12. **Differential Calculus.**

Summer Quarter.
ASSISTANT PROFESSOR YOUNG.

Prerequisite: *Courses 1, 2, 3 (Courses 3 and 12 may, however, be taken simultaneously).*

14. **Integral Calculus.**—A first view.

Summer Quarter.
MR. VEBLEN.

Prerequisite: *Differential Calculus.*

11, 13, 15. **Calculus I, II, III.**—The fundamental principles and processes of the differential and integral calculus, with much attention to the solving of problems illustrating all phases of the theory and certain important applications to geometry and mechanics and physics.

Three consecutive Majors. Autumn, Winter, and Spring Quarters; 8:30.

PROFESSOR MOORE.

Prerequisite: *Courses 1, 2, 3.*

NOTE.—Courses 11 and 17 may be taken simultaneously.

II. SENIOR COLLEGE COURSES.

17, 19. **Advanced Algebra, I, II.**—Rational functions. Binary quantics. Symmetric functions. Invariants. Separation of and numerical approximation to the roots of an equation. Determinants and theory of systems of linear equations. Geometric theory of the real and of the complex variable. Limits. Infinite series and products. Hypergeometric series. Continued fractions. Roots of unity.

2Mjs. Autumn and Winter Quarters.
PROFESSOR BOLZA.

Prerequisite: *Plane Analytics and Differential Calculus.*

NOTE.—Courses 11 and 17 may be taken simultaneously.

16. **Solid Analytics and Determinants.**

Summer Quarter.
DR. BOYD.

Prerequisite: *Plane Analytics and Calculus.*

NOTE.—Courses 12 and 16 may be taken simultaneously.

18. **Determinants.**—The elementary theory of determinants, together with certain important applications. M. First Term, Summer Quarter.

Prerequisite: *College Algebra.*

[Not to be given in 1901.]

20. **Theory of Equations.**—Based on Burnside and Panton's *Theory of Equations.*

Summer Quarter.

Prerequisite: *Analytic Geometry and Differential Calculus.*

[Not to be given in 1901.]

21. **Solid Analytics.** — Elements of analytic geometry of three dimensions. Quadric surfaces. Theory of curvature of twisted curves and surfaces.

Mj. Spring Quarter.
ASSISTANT PROFESSOR YOUNG.

Prerequisite: *Plane Analytics and Differential Calculus.*

[ASTRONOMY 5, 6.] **Analytic Mechanics I, II.** — Bowser's *Analytic Mechanics*, supplemented by lectures.

2Mjs. Autumn and Winter Quarters.
DR. LAVES.

Prerequisite: *Differential and Integral Calculus.*

23, 25, 27. **Advanced Integral Calculus I, II, III.**—Including ordinary differential equations, definite integrals, Fourier's series, and the elements of elliptic integrals and functions, and of partial differential equations, with especial attention to applications to geometry, mechanics, and physics.

2Mjs. Autumn, Winter, and Spring Quarters.
ASSISTANT PROFESSOR SLAUGHT.

Prerequisite: *Calculus and Advanced Algebra.*

24. **Advanced Integral Calculus.**— Including definite integrals and their geometric applications.

Mj. Summer Quarter.

Prerequisite: *Calculus.*

[Not to be given in 1901.]

27. **Differential Equations.**—Ordinary differential equations and elements of the theory of partial differential equations, with especial attention to certain important differential equations occurring in Astronomy and Physics.
Mj. Summer Quarter.
ASSISTANT PROFESSOR SLAUGHT.

III. GRADUATE COURSES.

30. **Conferences on the Pedagogy of Mathematics.** Selected topics from the teaching of preparatory and collegiate mathematics will be considered.
Mj. Summer Quarter.
ASSISTANT PROFESSOR YOUNG.

35 A, B, C. **Mathematical Reading and Research.** When it is advisable that students undertake definite mathematical reading and research not closely connected with any current lecture course or seminar, this work will be directed by one or other of
PROFESSORS MOORE, BOLZA, MASCHKE.

36. **Theoretical Mechanics.**—Advanced course in analytic mechanics, with reference-use of Appell's *Mécanique Rationelle.*
Mj. Spring Quarter.

Prerequisite: *Analytical Mechanics I, II, and Differential Equations.*

[Not to be given in 1901–2.]

38. **Selected Chapters of Algebra.**
ASSOCIATE PROFESSOR MASCHKE.

Prerequisite: *Courses 17, 19, 21, 23, 25.*

[Not to be given in 1901–2.]

40. **Calculus of Variations.**—An advanced course on the theory of maxima and minima of definite integrals, chiefly based upon Weierstrass' lectures, with numerous applications to problems of geometry and mechanics.
Mj. Summer Quarter; 11:00.
PROFESSOR BOLZA.

Prerequisite: *Advanced Integral Calculus*, and a facility in abstract mathematical reasoning.

41. **Quaternions.**—Introduction to the general theory, with applications to geometry and mechanics.
Mj. Summer Quarter.

Prerequisite: *Plane and Solid Analytics, and Calculus.*

[Not to be given in 1901.]

44. **Twisted Curves and Surfaces.**—Differential geometry. A course introductory to Course 76: Seminar C, Spring Quarter.
Mj. Winter Quarter.
ASSISTANT PROFESSOR MASCHKE.

Prerequisite: *Courses 21, 23, 25, and 27.*

45A. **Pure Projective Geometry.**—An introductory course based on Holgate's translation of the first volume of Reye's *Geometric der Loge.*
M. First Term; Summer Quarter.
ASSOCIATE PROFESSOR DICKSON.

45B. **Analytic Projective Geometry.**—An introductory course.
M. Second Term; Summer Quarter.
ASSISTANT PROFESSOR DICKSON.

46. **Modern Analytic Geometry.** — Homogeneous (trilinear) coördinates; projective properties of conics. Mj. Winter Quarter.
ASSOCIATE PROFESSOR MASCHKE.

Prerequisite: *Courses 11, 13, 15, 17, 19, 21, and 45.*

[Not to be given in 1902.]

47. **Higher Plane Curves.**—General properties of algebraic curves. Special study of the curves of the third and fourth order.
Mj. Spring Quarter.
ASSOCIATE PROFESSOR MASCHKE.

Prerequisite: *Course 46.*

[Not to be given in 1902.]

48. **Algebraic Surfaces.**—General theory. Most important properties of algebraic surfaces of the third order and of certain other general classes of surfaces. Line geometry.
Mj. Spring Quarter.
ASSOCIATE PROFESSOR MASCHKE.

Prerequisite: *Course 47.*

[Not to be given in 1902.]

49. **Lie's Theory of Differential Equations.**—The simplest notions of Lie's continuous groups, chiefly one-parameter groups, with extensive applications to the integration of ordinary and partial differential equations.
ASSISTANT PROFESSOR DICKSON.

Prerequisite: *Courses 21, 23, 25, 27.*

[Not to be given in 1901–2.]

49A. **Continuous Groups.**—Lie's theory with its applications to geometry, invariant-theory, differential equations, systems of complex numbers, and non-euclidean geometries.

Assistant Professor Dickson.

Prerequisite : *Course 49.*

[Not to be given in 1901–2.]

50. **Theory of Invariants.** — Linear substitutions; theory of quantics ("modern higher algebra"), with applications to the theory of equations and to geometry. Mj. Autumn Quarter.

Associate Professor Maschke.

Prerequisite : *Courses 17, 19, 23, 25.*

51. **Theory of Functions of a Complex Variable.**—The elements of the theories of Cauchy and of Weierstrass. Mj. Summer Quarter.

Professor Bolza.

Prerequisite : *Courses 19, 21, and 23.*

52, 52A. **Theory of Functions, I, II.**—I : Complex numbers. The linear fractional function. Conform representation. The limit notion. Critical review of the principles of the infinitesimal Calculus. Infinite series and products. Definite integrals. — II : Cauchy's theory of functions of a complex variable. Power series. Elements of Weierstrass' theory of analytic functions. Riemann's surface.

2Mjs. Autumn and Winter Quarters.

Associate Professor Maschke.

Prerequisite : *Courses 17, 19, 21, 23, 25, 27.*

52B. **Theory of the Potential.**—With applications to problems of mechanics and physics. Spherical and cylindrical harmonics, with application to the theory of the potential.

Mj. Spring Quarter.

Mj. Autumn Quarter.

Associate Professor Maschke.

Prerequisite : *Courses 52, 52A.*

53. **Theory of Functions of Real Variables.** — Critical exhibition of the fundamental properties of the real variable and of certain classes of functions of real variables. A course introductory to Seminar A : Winter and Spring Quarters.

Mj. Autumn Quarter.

Professor Moore.

Prerequisite: *Courses 19, 21, and 23,* and a facility in abstract mathematical reasoning.

54. **Linear Differential Equations.**—The general theory with particular reference to differential equations of second order. Special study of the hypergeometric function.

Mj. Spring Quarter.

Associate Professor Maschke.

Prerequisite : *Course 52A.*

[Not to be given in 1902.]

55. **Elliptic Functions.**—Weierstrass' theory.

Mj. Winter Quarter.

Professor Bolza.

Prerequisite: *Course 53.*

[Not to be given in 1902.]

55A. **Applications of Elliptic Functions.** — A continuation of Course 55.

Mj. Spring Quarter.

Professor Bolza.

[Not to be given in 1902.]

56. **Hyperelliptic Functions.**—According to Riemann and Klein. Mj. Summer Quarter.

Dr. McDonald.

Prerequisite: *Course 53.*

57. **Abelian Functions.**—A course introductory to Course 73 : Seminar B, Winter Quarter.

Mj. Autumn Quarter.

Professor Bolza.

Prerequisite : *Course 52A.*

58. **Linear Substitution Groups.**—The fundamental principles of the theory of groups. Deduction and discussion of binary, ternary, and certain quaternary substitution groups of finite order. Associate Professor Maschke.

Prerequisite: *Courses 47 and 52A.*

[Not to be given in 1901–2.]

59. **Abstract Groups.**—In connection with the literal and the linear substitution groups, and with application to the theory of algebraic equations.

Professor Moore.

Prerequisite: No specific subjects, but a facility in abstract mathematical reasoning.

[Not to be given in 1901–2.]

59A. **Elliptic Modular Functions.** — A sketch of the general theory of the modular equation, with especial attention to certain illustrative algebraic and transcendental resolvents.

Professor Moore.

Prerequisite : *Courses 52A, 55, and 59.*

[Not to be given in 1901–2.]

60. **Theory of Substitutions,** with applications to the Theory of Algebraic Equations.
PROFESSOR MOORE.
[Not to be given in 1901–2.]

61. **Theory of Numbers.**—The elements of the theory, with an introduction to the theory of congruence groups. Mj. Spring Quarter.
ASSISTANT PROFESSOR DICKSON.

Prerequisite: No specific subjects, but a facility in abstract mathematical reasoning.

62, 63. **General Arithmetic I, II.**—The theory of integral functions of indeterminates with integral coefficients, with application to the theory of algebraic numbers and functions.
2Mjs. Winter and Spring Quarters.
PROFESSOR MOORE.

Prerequisite: *Course 61.*
[Not to be given in 1902.]

64. **Algebraic Numbers.**—The classical theories and current researches. Hilbert's report "Die algebraischen Zahlkörper" (Berlin, Reimer, 1897) should be in the hands of the student. This course presupposes Course 61.
PROFESSOR MOORE.
[Not to be given in 1901–2.]

THE SEMINARS.

Advanced students engaged in or prepared to undertake research work may, on approval of its Director, enter one of the Seminars. The individual members of a Seminar from time to time report to the Seminar on their investigations or on assigned topics. Each Seminar considers in particular certain topics; these topics vary somewhat from year to year. The research work of candidates for the doctorate receives particular attention and direction.

70, 71. **Seminar A, I, II.**—Selected topics in the theory of functions of real variables.
2Mjs. Winter and Spring Quarters.
PROFESSOR MOORE.

Prerequisite: *Course 53.*

73. **Seminar B.**—Selected topics in the theory of Abelian functions.
Mj. Winter Quarter.
PROFESSOR BOLZA.

Prerequisite: *Course 57.*

76. **Seminar C.**—Selected topics in differential geometry.
Mj. Spring Quarter.
ASSOCIATE PROFESSOR MASCHKE.

Prerequisite: *Course 44.*

XVIII. THE DEPARTMENT OF ASTRONOMY AND ASTROPHYSICS.

OFFICERS OF INSTRUCTION.

GEORGE ELLERY HALE, Sc.D., *Professor of Astrophysics, and Director of the Yerkes Observatory.*

SHERBURNE WESLEY BURNHAM, A.M., *Professor of Practical Astronomy, and Astronomer in the Yerkes Observatory.*

EDWARD EMERSON BARNARD, A.M., Sc.D., *Professor of Practical Astronomy, and Astronomer in the Yerkes Observatory.*

EDWIN BRANT FROST, A.M., *Professor of Astrophysics, and Astrophysicist in the Yerkes Observatory.*

KURT LAVES, Ph.D., *Assistant Professor of Astronomy.*

FOREST RAY MOULTON, A.B., Ph.D., *Instructor in Astronomy.*

GEORGE WILLIS RITCHEY, *Instructor in Practical Astronomy, and Superintendent of Instrument Construction at the Yerkes Observatory.*

FERDINAND ELLERMAN, *Instructor in Astrophysics at the Yerkes Observatory.*

STORRS BARROWS BARRETT, *Secretary and Librarian of the Yerkes Observatory.*

JOHN ADELBERT PARKHURST, *Assistant at the Yerkes Observatory.*

WALTER SIDNEY ADAMS, *Assistant at the Yerkes Observatory.*

FELLOWS.

1901-1902.

WILLIAM OTIS BEAL, A.M.

INTRODUCTORY.

The work of the Department of Astronomy and Astrophysics naturally divides itself into two parts:

1. Work at the University, comprising: (*a*) elementary instruction in general Astronomy, both theoretical and practical; (*b*) preliminary training in the principles and methods of work underlying the science of Astrophysics, given in the undergraduate and graduate courses offered by the Department of Physics; (*c*) graduate and research work in Celestial Mechanics.

2. Graduate and research work in the Yerkes Observatory at Lake Geneva.

UNIVERSITY WORK.

In the work at the University, which will be given by Dr. Laves and Dr. Moulton, special emphasis will be laid on the development of the mathematical methods and principles which lie at the basis of the physical sciences. In addition to the annual courses in Descriptive Astronomy, Introduction to Celestial Mechanics, Spherical and Practical Astronomy, Orbits and Ephemerides, and Analytical Mechanics, courses in the various branches of Celestial Mechanics will be given within periods not exceeding three years. The most fundamental subjects will be arranged in a cyclic manner so as to recur at regular intervals, while other more special topics will vary from time to time.

The general object of the instruction will be: (1) to furnish the student an adequate mathematical basis for successful work in Celestial Mechanics; (2) to give such experience and preliminary training in the work of observation and reduction as will enable the student to use intelligently and skillfully any of the astronomical or astrophysical instruments of a modern observatory; (3) to direct the attention of advanced students to the fundamental problems of modern Astronomy and Astrophysics, and to encourage work of research likely to yield contributions to science.

OBSERVATORY WORK.

In the work at the Observatory attention will be devoted both to the investigations of Practical Astronomy and to those of Astrophysics. The rapid development of the latter science within the last few years has been fully recognized and amply provided for in the design of the Observatory and in its instrumental equipment. The special laboratory facilities will render possible many astrophysical investigations which are necessarily neglected in other institutions. The Observatory will be open to those students only who have completed the necessary preliminary work at the University or its equivalent at other institutions.

GRADUATE AND RESEARCH WORK.

Undergraduate Students, in the S.B. course, who desire to specialize along the line of Astronomy, are recommended to take *six Majors* in Mathematics, viz.: Differential and Integral Calculus 3; Solid Analytic Geometry 1; Advanced Integral Calculus 2; and *three Majors* in Astronomy, viz.: Descriptive Astronomy, Introduction to Celestial Mechanics, and Spherical and Practical Astronomy.

Graduate Students working for the Master's degree are recommended to choose *three Majors* in the Department of Mathematics, viz.: Differential Equations 1; Theory of Equations 2; or in the Department of Physics, viz.: Advanced General Physics 3; and *six Majors* in the Department of Astronomy.

Candidates for the degree of Doctor of Philosophy are expected to make their secondary subject either Mathematics or Physics. Students intending to specialize in the lines of Astrophysics will be required to take the work in Advanced General Physics, Advanced Laboratory Practice, Laboratory Methods, and Spectrum Analysis.

SCHOLARSHIPS, FELLOWSHIPS, DOCENTSHIPS.

Graduate Scholarships, Fellowships, and Docentships, will be assigned in accordance with the general regulations of the University. Details regarding the appointments of Volunteer Research Assistants and Special Investigators at the Yerkes Observatory may be found on page 16 of this PROGRAMME.

DEPARTMENTAL CLUB.

The Club meets fortnightly on Fridays at 4:00 P.M. in the Ryerson Physical Laboratory, Room 35, for the review of memoirs and books, and for the presentation of results of research. The Club is conducted by the members of the Faculties of Mathematics and Mathematical Astronomy. Graduate students of Mathematical Astronomy are expected regularly to attend and, so far as possible, actively to participate in the meetings of the Club.

EQUIPMENT.

The Department of Astronomy at the University occupies at present rooms on the third floor of the Ryerson Physical Laboratory. For the purpose of instruction in Practical Astronomy a Students' Observatory, consisting temporarily of two small buildings, has been provided on the northeastern quadrangle. It is equipped with a modern Warner and Swasey equatorial telescope of 6½-inch aperture, provided with a filar micrometer with position circle, a Bamberg universal instrument, a chronometer, and various smaller accessories. The laboratory courses offered by the Department of Physics afford the best preliminary training for the work in Astrophysics.

A description of the Yerkes Observatory at Lake Geneva and its equipment will be found on pages 15–16 of this PROGRAMME.

LIBRARY FACILITIES.

The Astronomical Library is open to graduate students under the same conditions as the Mathematical Library, with which it is associated. The Astronomical Library includes many of the fundamental works on Astronomy, several sets of annals, and a number of journals.

PUBLICATIONS.

The publications of the Department are enumerated in the description of the Observatory.

COURSES OF INSTRUCTION,

Summer Quarter, 1901 — Spring Quarter, 1902.

M=Minor course=a single course for six weeks. DM=Double Minor course=a double course (two hours daily) for six weeks. Mj=Major course=a single course for twelve weeks. DMj=Double Major course=a double course for twelve weeks.

At the University.

I. JUNIOR COLLEGE COURSES (1–4).

1. **Popular Lectures.**

3. **Descriptive Astronomy.**— An elementary course, dealing with fundamental facts, principles, and methods. Mj. Summer Quarter; 7:30.
Mj. Winter Quarter; 8:30.
DR. MOULTON.

Prerequisite: *College Algebra, and the Elements of Physics.*

II. SENIOR COLLEGE COURSES (5–20).

5, 6. **Analytic Mechanics.** — Two consecutive quarters. An introductory course based on Bowser's *Analytic Mechanics*, supplemented by lectures.
Mj. Autumn Quarter; 2:00.
Mj. Winter Quarter; 2:00.
ASSISTANT PROFESSOR LAVES.

Prerequisite: *Differential and Integral Calculus.*

7. **Introduction to Celestial Mechanics.** — Central forces; demonstration of law of gravitation; problem of two bodies; the ten integrals of planetary motion; considerations on perturbations; theory of double-star orbits; Helmholtz theory of the heat of the sun.
Mj. Winter Quarter; 9:30.
DR. MOULTON.

Prerequisite: *Calculus.*

8. **Spherical and Practical Astronomy.**—The theory of instruments with practical applications; the corrections of observations and the use of star catalogues. Mj. Spring Quarter; 2:00.
ASSISTANT PROFESSOR LAVES.

Prerequisite: *XVII, 1–3.*

9. **Observatory Work.**—Practice with the Equatorial and with the Universal Instrument in the Students' Observatory. Mj. Summer Quarter.
MR. LUNN.
Mj. Winter Quarter.
ASSISTANT PROFESSOR LAVES.

Prerequisite: *Courses 3 and XVII–1, 2.*

III. GRADUATE COURSES (21–50).

[MATHEMATICS 36.] **Theoretical Mechanics.**
Mj. Spring Quarter; 8:30.
———.

23. **Theory of Orbits and Special Perturbations.** Properties of conic section motion; determination of two geocentric distances from the observations; determination of elements, and methods of improving them; variations of elements; perturbations of rectangular and polar coördinates; numerical differentiation and integration. Mj. Spring Quarter; 8:30.
DR. MOULTON.

Prerequisite: *General Astronomy and Differential and Integral Calculus.*

34A. **The Theory of Absolute Perturbations II.**—The methods of Hansen and Gyldin.
Mj. Autumn Quarter; 3:00.
ASSISTANT PROFESSOR LAVES.

35. **The Lunar Theory.**—An account of the principal older theories; special study of the methods of Delaunay and Hill.
Mj. Spring Quarter; 9:30.
DR. MOULTON.

41. **The Theory of Attractions and Figures of the Heavenly Bodies.**
Mj. Winter Quarter; 3:00.
ASSISTANT PROFESSOR LAVES.

At the Yerkes Observatory.

In the work at the Yerkes Observatory the advanced student is made familiar with modern methods of research in various branches of Practical Astronomy and Astrophysics. In general, the work in progress during the year 1901–2 will probably include: researches in solar physics with the spectroscope, spectroheliograph, photoheliograph, and radiometer; micrometric observations of double stars, planets, satellites, nebulæ, and comets; photographic studies of stellar spectra; photographs of star clusters, nebulæ, etc.; special astrophysical investigations. On account of the nature of the Observatory's work, it is possible that the subjoined outline of courses will require some modification. Graduate students wishing to take any of the courses should consult the Director of the Yerkes Observatory, Williams Bay, Wis., before making a selection.

Hours are to be arranged with the instructor.

GRADUATE COURSES.

51. **Astronomical Spectroscopy.**—This is a general course on the applications of the spectroscope in astronomy, with practical work. Mj.
PROFESSOR FROST.

Prerequisite: *Practical Astronomy, Advanced Physics and Laboratory Practice, Spectrum Analysis.*

52, 53, 54, 55. **Solar Physics.**—This course includes systematic observational work with the telescope and spectroscope, supplemented by constant reference to the literature of the subject.

52. Visual and photographic study of the solar photosphere, spots, and faculæ. Use of the photoheliograph. DMj. Summer Quarter.

53. Visual and photographic observations of the chromosphere, prominences, faculæ, and spots with the solar spectroscope and spectroheliograph. DMj. Autumn Quarter.

54. Measurement and reduction of photographs made with the solar spectrograph, photoheliograph, and spectroheliograph.
DMj. Winter Quarter.

55. Spectroscopic observations of sun-spots, including the systematic study of widened lines. DMj. Spring Quarter.
PROFESSOR HALE.

Prerequisites: Same as for *Astronomical Spectroscopy.*

56, 57. **Stellar Spectroscopy.**—These courses, like the preceding ones, consist of systematic observational work combined with a constant study of original memoirs. In both courses the student will assist in making and in measuring photographs of stellar spectra.

56. (1) A visual and photographic study of stellar spectra, with special reference to stars of Secchi's Fourth Type.
3DMjs. Autumn, Winter, and Spring Quarters. PROFESSOR HALE.

57. (2) The photographic determination of stellar motions in the line of sight.
DMj. Summer Quarter.
2DMjs. Autumn and Spring Quarters.
PROFESSOR FROST.

58. **Celestial Photometry.**—A course dealing mainly with the theoretical principles, and based upon Müller's *Photometrie der Gestirne.*
Mj. Autumn Quarter.
PROFESSOR FROST.

59. **Astronomical and Astrophysical Research.**—Students qualified for research will be given opportunity for special investigations in Astronomy and Astrophysics.
PROFESSORS HALE, BARNARD, AND FROST.

THE YERKES ASTRONOMICAL OBSERVATORY.

OFFICERS OF GOVERNMENT.

GEORGE ELLERY HALE, *Professor of Astrophysics, and Director.*
SHERBURNE WESLEY BURNHAM, *Professor of Practical Astronomy, and Astronomer.*
EDWARD EMERSON BARNARD, *Professor of Practical Astronomy, and Astronomer.*
EDWIN BRANT FROST, *Professor of Astrophysics, and Astrophysicist.*
GEORGE WILLIS RITCHEY, *Instructor in Practical Astronomy and Superintendent of Instrument Construction.*
FERDINAND ELLERMAN, *Instructor in Astrophysics.*
STORRS BARROWS BARRETT, *Secretary and Librarian.*
JOHN ADELBERT PARKHURST, *Assistant.*
WALTER SIDNEY ADAMS, *Assistant.*

J. A. JOHANNESEN, *Instrument Maker.*
F. R. SULLIVAN, *Engineer in Charge of 40-Inch Telescope.*

ERNEST FOX NICHOLS, Sc.D. (Professor of Physics, Dartmouth College), *Special Investigator* (Summer Quarter, 1900).
CAROLINE E. FURNESS, Ph.D. (Instructor in Astronomy, Vassar College), *Volunteer Research Assistant* (Summer Quarter, 1900).
STANLEY C. REESE, Ph.D., *Volunteer Research Assistant.* (Summer and Autumn Quarters, 1900.)

THE OBSERVATORY.

The Yerkes Observatory was founded in 1892, through the munificence of Mr. Charles T. Yerkes, of Chicago. Its principal instrument is a refracting telescope of 40 inches' aperture, which is provided with the following attachments:

1. A position micrometer.
2. A wedge photometer.
3. A double-slide plate-holder, with color screen, for direct photography of the sun, moon, stars, nebulæ, etc.
4. A solar spectrograph, for micrometrical and photographic investigations of the spectra of solar phenomena.
5. A spectroheliograph, for photographing the solar chromosphere, prominences, and faculæ by monochromatic light.
6. A stellar spectrograph, for researches on the spectra and motions of stars, nebulæ, comets, and planets.

The construction of the main building of the Observatory was completed in 1897. Its form is that of a Latin cross, with three domes and a meridian room at the extremities. The principal axis (about 330 feet long) of the building lies east and west, with the dome for the 40-inch telescope at the western end. This dome is 90 feet in diameter, allowing ample space for the tube of the great telescope, which, with its attachments, is nearly 70 feet long. The elevating floor of the observing room is 75 feet in diameter, and is movable through a range of 23 feet by means of electric motors.

Of the two smaller domes, the one to the northeast contains the 12-inch telescope formerly at the Kenwood Observatory, and in the other is mounted a 24-inch reflector. Between these domes is the heliostat room, 100 feet long by 12 feet wide. A large heliostat stands on a pier at the north end of the room, under an iron roof, which can be rolled away to the south.

The meridian room has double sheet-iron walls, with an intervening air space. It is designed to contain a meridian circle of large aperture, but for the present a transit instrument suffices for the purposes of the Observatory.

The body of the building is divided through the center by a hallway extending from the meridian room to the great tower. On either side are offices and computing rooms, a library, lecture-room, two spectroscopic laboratories, dark room, developing room, galvanometer room, chemical laboratory, instrument rooms, etc. In the basement is a large photographic dark room, an enlarging room, concave grating room with large concave grating spectroscope, emulsion room, constant temperature room, physical laboratory, and óptician's room. The engines, dynamos, and boilers for supplying heat and power are in the power-house at a distance of several hundred feet from the Observatory.

Much of the special apparatus needed for the researches conducted at the Observatory is constructed by the mechanicians under the supervision of Mr. Ritchey. For this purpose a large workshop has been provided, equipped with a complete outfit of instrument-maker's tools, including an 8-inch Rivett precision lathe, Blaisdell engine lathe, Brown & Sharpe universal milling machine, planer, drill-press, shaper, circular saw, speed-lathe, etc.

The Observatory is situated about a mile from the town of Williams Bay, near Lake Geneva, Wisconsin, in an ideal rural region, free from the dust and smoke of cities and removed from the tremors of railroad traffic. Lake Geneva is about seventy-five miles from Chicago, and is reached by a branch of the North-Western Railroad. The site of the Observatory includes about fifty acres of wooded land fronting on the lake.

OPPORTUNITIES FOR STUDENTS.

Advanced students in Astronomy and Astrophysics are offered every possible opportunity to profit by the instrumental facilities of the Yerkes Observatory. In addition to the regular courses of instruction, opportunities to take part in the investigations in progress at the Observatory are freely accorded to all students who are qualified for such work. As soon as capacity for original research has been sufficiently developed, students are encouraged to undertake investigations of their own.

SPECIAL INVESTIGATORS.

The facilities enjoyed at the Yerkes Observatory for the prosecution of special researches in various fields of Astronomy and Astrophysics are in some cases of an exceptional nature. It has accordingly been felt that, so far as this can be done without interfering with the regular work of the members of the staff, opportunity should be given to men of science connected with other institutions to carry on special investigations at the Observatory. The Director has been authorized to extend invitations to undertake such special work to those who may seem likely to make good use of the opportunities thus afforded.

VOLUNTEER RESEARCH ASSISTANTS.

It may not infrequently be the case that students who have taken higher degrees in Astronomy, Astrophysics, or Physics, or have completed advanced studies in these subjects at The University of Chicago or some other institution, will find it to their advantage to spend some time at the Yerkes Observatory, in order to familiarize themselves with its work. To meet this need the position of Volunteer Research Assistant has been established. Those who are appointed to this position are expected to carry on such work as may be assigned to them during their connection with the Observatory. They receive no pay for their services, but are given every reasonable opportunity to become acquainted with the investigations in progress, and in some cases to conduct researches of their own.

PUBLICATIONS OF THE OBSERVATORY.

The publications of the Observatory include: *Bulletins of the Yerkes Observatory*, containing announcements of results and discoveries, brief descriptions of new buildings and instruments, and notes on the work of the Observatory; *Contributions from the Yerkes Observatory*, consisting of papers contributed to various astronomical and astrophysical periodicals and the proceedings of societies; *Publications of the Yerkes Observatory*, in the form of quarto volumes containing detailed accounts of special researches (Vol. I, A General Catalogue of 1290 Double Stars, discovered by S. W. Burnham, has recently been published); and *The Astrophysical Journal*, an International Review of Spectroscopy and Astronomical Physics, now in its thirteenth volume.

OBSERVATORY LIBRARY.

The library contains sets of many of the astronomical periodicals, charts, star catalogues, annals of observatories, and numerous general works.

The University will be glad to answer inquiries from institutions looking for well-equipped teachers of Mathematics, and of Astronomy and Astrophysics.

Letters of inquiry and requests for documents should be addressed to

THE UNIVERSITY OF CHICAGO,
CHICAGO, ILL.

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1901-022

The University of Chicago
FOUNDED BY JOHN D. ROCKEFELLER

PROGRAMME

OF THE DEPARTMENTS OF

PHYSICS AND CHEMISTRY

1901-1902

CHICAGO
The University of Chicago Press
1901

XIX. THE DEPARTMENT OF PHYSICS.

OFFICERS OF INSTRUCTION.

ALBERT ABRAHAM MICHELSON, Ph.D., *Professor and Head of the Department of Physics.*
SAMUEL WESLEY STRATTON, S.B., *Professor of Physics.*
CHARLES RIBORG MANN, Ph.D., *Instructor in Physics.*
ROBERT A. MILLIKAN, Ph.D., *Instructor in Physics.*
GLENN MOODY HOBBS, S.B., *Instructor in Physics.*
HENRY GORDON GALE, Ph.D., *Associate in Physics.*

FELLOWS

1901-1902.

FRANK BALDWIN JEWETT, A.B.
BENJAMIN OSCAR HUTCHISON, A.B.
MARY ISABEL NORTHWAY, A.B.
JOHN MILLS, A.B.

OSCAR LANGE, *Mechanician.*
JULIUS PEARSON, *Assistant Mechanician.*

INTRODUCTORY.

Within the last twenty years the teaching and practice of Physics has undergone a revolution more complete than that of any of its sister sciences. This result may be attributed, to a very great extent, to the enormous development of its applications to electrical industries. No other industrial application since the invention of the steam-engine has so enhanced the appreciation of the importance of exact knowledge, or given a greater impetus to the search for new truths in the unexplored regions on the borderland of science.

So closely interwoven are the advances in pure science and its applications that it is difficult to say which has been of greater service to the other, but it is evident that it is as ill-advised to ignore the powerful stimulus furnished by the practical development of scientific ideas as it is to belittle the influence which theoretical and experimental science have had on the world's material prosperity.

While it is never safe to affirm that the future of Physical Science has no marvels in store even more astonishing than those of the past, it seems probable that most of the grand underlying principles have been firmly established, and that further advances are to be sought chiefly in the rigorous application of these principles to all the phenomena which come under our notice.

It is here that the science of measurement shows its importance—where quantitative results are more to be desired than qualitative work. An eminent physicist has remarked that the future truths of Physical Science are to be looked for in the sixth place of decimals.

In order to make such work possible, the student and investigator must have at his disposal the methods and results of his predecessors, must know how to gauge them, and to apply them to his own work; and especially must he have at his command all the modern appliances and instruments of precision which constitute a well-equipped laboratory—without which results of real value can be obtained only at immense sacrifice of time and labor.

The science of Astronomy appeals far more powerfully to most people than does Physical Science, which, indeed, to many is scarcely known even by name. The former is as old as history. Its wonders have compelled the attention of mankind from the earliest ages, and it is but a natural consequence that at the present day no important city in the civilized world is without a richly endowed observatory, where a trained corps of astronomers are able to study the phenomena of the life of suns and worlds, and their distribution in time and space.

It is only in very recent times that it has begun to dawn upon the mind of man that there is another world only one degree less complex and wonderful than the stellar universe — the world of molecules and atoms. For the study of these almost infinitesimal systems of pigmy stars we have no telescope nor even microscope to help us; but little by little we are constructing a powerful logical engine which is destined one day to bring the revolutions, rotations, and oscillations of these minute orbs as clearly to the mind's eye as are now the motions of the worlds of the greater, visible universe.

It may be said that this is, in fact, our chief problem—the constitution of matter; and while ultimately this is, and must always be, beyond the scope of our powers, it is as legitimate and worthy an object to extend our knowledge step by step in this direction as to increase our knowledge of the structure of the sidereal universe, even though this can never be completely fathomed.

As in the case of Astronomical observatories the work, while chiefly devoted to furthering the interests of pure science, is nevertheless consistent with the furnishing of valuable information of immediate practical utility, so a Research Laboratory, while carefully preserving its chief and essential feature, may be still practically useful in furnishing authoritative measurements of standards of length, mass, and time, calibration of thermometers, pressure-gauges, comparison of standards, of resistance, electro-motive force, capacity, self-induction, etc.

It is hoped that this outline of the aims and ends of a Physical Research Laboratory, partial and incomplete though it be, may justify the hope and belief that the generosity of the founder of the University and the donor of the Ryerson Physical Laboratory will be supplemented by many other liberally minded men, equally disposed to further so worthy a cause.

In the enthusiasm which inevitably accompanies the work of the investigator, that of the instructor will not be ignored; indeed, it is confidently expected that these two functions will mutually assist each other.

The courses of instruction to be given in the Department of Physics, it is believed, are sufficiently varied to suit the requirements of all classes, including those who desire simply to complete a general education, or to undertake the subject as a disciplinary study; those who wish to pursue it as a preliminary to its application to mechanical, electrical, or civil engineering; or those who intend to make it their life-work.

In each case every opportunity will be taken to present the subject in such a way as to impress the student with the reality of the principles and laws expounded by well-chosen experiments, performed by the instructor, and whenever possible by the student himself.

A feature on which considerable stress will be laid is the repetition of the classical experiments of eminent investigators by those graduate students who are able to undertake them.

It is believed that by this means a great deal of valuable experience will be gained, without the vexatious annoyances encountered in entering upon an original investigation, before having the benefit of such preliminary training.

For a description of the Ryerson Physical Laboratory, see p. 7 of this Programme.

FELLOWSHIPS AND GRADUATE SCHOLARSHIPS.

The University appoints each year a limited number of fellowships and graduate scholarships. Detailed information concerning these and the conditions of their appointment may be obtained by communicating with The University of Chicago.

COURSES OF INSTRUCTION.

Summer Quarter, 1901—Spring Quarter, 1902.

M=Minor course=a single course for six weeks. DM=Double Minor course=a double course (two hours daily) for six weeks. Mj = Major course = a single course for twelve weeks. DMj = Double Major course=a double course (two exercises daily) for twelve weeks.

Junior College Courses.

1. **General Physics.**—A course in General Physics in which are presented mainly from the experimental standpoint the most important principles involved in the study of mechanics, properties of liquids and gases, heat and sound.

10 hrs. a week. Mj. Each quarter.

Summer Quarter; 8:30–10:30. Mr. Hobbs.

11:00–1:00. Dr. Gale.

Autumn Quarter; 8:30–10:30.
Dr. Millikan, Mr. Hobbs, and Dr. Gale.

Winter and Spring Quarters; 8:30–10:30.
Mr. Hobbs and Dr. Gale.

Prerequisite: *Plane Trigonometry and Elementary (Entrance) Physics.*

2. **General Physics.**—A continuation of Course 1 covering the subjects of electricity and light.

10 hrs. a week. Mj. Summer Quarter; 2:00–4:00. Dr. Millikan and Mr. Hobbs.

Repeated. Mj. Winter Quarter, 2:00–4:00.
Dr. Millikan and Mr. Hobbs.

Prerequisite: *General Physics 1.*

3. **General Physics.**—A course of lectures and demonstrations intended to complete a year's work in Junior College Physics. The most important principles of Physics not treated in Courses 1 and 2 are presented from the lecture standpoint.

5 hrs. a week. Mj. Spring Quarter; 9:30.
DRS. MANN AND MILLIKAN,
with occasional lectures by
PROFESSOR MICHELSON.

Prerequisite: *General Physics 1 and 2.*

4. **Normal Course in Preparatory Physics.** — A model course in Elementary Physics for secondary schools, designed especially to assist teachers in the presentation of the subject. No university credit is given for this course.

Mj. Summer Quarter; 2:00–4:00.
DR. GALE.

SENIOR COLLEGE COURSES.

11. **Molecular Physics.**—A lecture course for advanced and graduate students, covering the Kinetic Theory of Gases, Capillarity, Solution, and the Ionic Theory of Galvanic Action.

Mj. Autumn Quarter 11:00.
DR. MILLIKAN.

Prerequisite: *General Physics, 1, 2, and 3, Differential and Integral Calculus.*

12. **Sound and Light.**—A lecture course for advanced and graduate students covering the subjects of sound, music and the more important sections of geometrical and physical optics.

5 hrs. a week. Mj. Winter Quarter; 11:00.
DR. MANN.

Prerequisite: *Differential and Integral Calculus, Physics 1, 2, and 3.*

13. **Electricity and Magnetism.** — A course of advanced work in theoretical Electricity and Magnetism, intended to supplement the work in General Physics or prepare for the graduate work.

5 hrs. a week. Mj. Spring Quarter; 11:00.
PROFESSOR STRATTON.

Prerequisite: *Differential and Integral Calculus, Physics 1, 2, and 3.*

14. **General Physics.** — A course in General Physics in which only the more important parts of the subject are taken up. Especial attention is given to methods of demonstration suitable for college courses in General Physics.

Mj. Summer Quarter; 9:30.
PROFESSOR STRATTON.

Prerequisite: *Physics 1 and 2.*

16. **Experimental Physics** (Advanced).—*Fundamental Measurements.* — A course consisting of the better class of measurements of mass, length, and time, the determination of the constants of elasticity, molecular physics and heat.

10 hrs. a week. Mj. Autumn Quarter; 2:00–4:00.
DR. MILLIKAN.

Prerequisite: *Differential and Integral Calculus, Physics 1, 2, and 3.*

17. **Experimental Physics** (Advanced). — *Light.* — A course of advanced laboratory work in Light, consisting of accurate measurements in diffraction, dispersion, interference, and polarization.

10 hrs. a week. Mj. Winter Quarter; 2:00–4:00.
DR. MANN.

Prerequisite: *Differential and Integral Calculus, Physics 1, 2, and 3.*

18. **Experimental Physics** (Advanced). — *Electricity and Magnetism.*—Laboratory work of the same grade as Courses 16 and 17, but consisting of measurements in Electricity and Magnetism.

10 hrs. a week. Mj. Spring Quarter; 2:00–4:00.
DR. MANN.

Prerequisite: *Differential and Integral Calculus, Physics 1, 2, and 3.*

19. **Experimental Physics** (Advanced). — Students registering for this course are permitted to select such problems from Courses 16, 17, and 18, as they desire, subject to the approval of the instructor.

10 hrs. a week. Mj or DMj. Summer Quarter; 2:00–4:00.
DRS. MILLIKAN AND GALE.

Prerequisite: *Physics 1, 2, and 3.*

20. **Physical Manipulation.** — A series of exercises not provided for in the regular courses of Experimental Physics, but exceedingly important to the teacher or advanced student consisting of the following groups:

Group A. *Shop Work* includes the cutting, filling, drilling, tapping, soldering, and polishing of metal, screw cutting, and elementary lathe work.

Group B. *Glass Work* includes the cutting, grinding, drilling, polishing, and testing of glass.

Group C. *Glass Blowing* includes the simpler processes in glass blowing, such as cutting, bending, and joining of tubes, blowing bulbs, sealing in electrodes, etc.

Group D. *Chemical Processes and Physical Preparations* includes the silvering of glass, cleaning and distillation of mercury, preparation of fibers for suspension, and materials useful in experimental work.

10 hrs. a week, Mj. Summer Quarter; 11:00–1:00. Mr. Hobbs.

Note. — Mr. Hobbs will be assisted, during the Summer Quarter, by specialists in Groups A, B, and C. A laboratory fee of $5.00 will be charged for this course.

Repeated. Mj. Winter Quarter; 11:00–1:00. Dr. Mann.

Prerequisite: *Physics 1, 2, and 3.*

21. **Experimental Physics.** — An advanced course in electricity and magnetism including the ordinary measurements of capacity, mutual and self-induction, intensity of magnetic fields, and the magnetic properties of a substance.

10 hrs. a week. Mj. Spring Quarter; 2:00–4:00. Professor Stratton.

Prerequisite: *Physics 13 and 18.*

24. **Mechanical Drawing.** — A course designed to acquaint the student with the principles of mechanical drawing and projection, the preparation of working sketches and drawings, and elementary curve tracing.

10 hrs. a week. Mj. Summer Quarter; 3:00–5:00. Mr. Jewett.

Spring Quarter; 3:00–5:00. Mr. ———.

Graduate Courses.

30, 31. **Theoretical Physics.**— A series of lectures, chiefly in Theoretical Physics. Hydrodynamics, Elasticity, Capillarity, Molecular Physics, Thermodynamics, Wave-motion and Sound, Optical Theories, Electricity and Magnetism.

4 hrs. a week. Mj. Winter Quarter; 12:00. Professor Michelson.

Prerequisite: *Physics 11, 12, and 13.*

32. **Experimental Physics.** — A course of laboratory work, chiefly devoted to the repetition of classical experiments, such as: Determination of the Mechanical Equivalent of Heat, Maxwell's "V" Hertzian Oscillation, Relative and absolute Wave-lengths, etc.

10 hrs. a week. Mj. Every quarter. Professor Michelson.

Prerequisite: *Physics, 16, 17, and 18.*

33. **Research Course.** — This course is intended for those graduate students who are prepared to undertake special research.

Except in the case of a purely mathematical problem, the entire time is to be devoted to work in the laboratory.

20 hrs. a week. Every quarter.

DM. First Term, Summer Quarter. Professor Michelson.

3DMjs. Autumn, Winter, and Spring Quarters. Professor Michelson.

34. **Spectrum Analysis.** — This course treats the conditions affecting purity, brightness of spectra, the resolving power of prisms and gratings, the theory of gratings and the effect of temperature and density, on emission and absorption spectra.

M. First Term, Spring Quarter; 12:00. Professor Michelson.

35. **Interference Methods and their Application.** — A general treatment of the problem of interference, and of the various forms of *interferometer*, and a discussion of how light-waves may be most advantageously employed as a means of research.

M. Second Term; Spring Quarter; 12:00. Professor Michelson.

36. **Thermodynamics.** — Lectures upon the fundamental principles underlying the mechanical theory of heat and the application of these principles to physical and thermochemical problems.

5 hrs. a week. Mj. Summer Quarter; 11:00. Dr. Millikan.

THE RYERSON PHYSICAL LABORATORY.

OFFICERS OF GOVERNMENT.

ALBERT ABRAHAM MICHELSON, *Professor and Head of the Department of Physics.*
SAMUEL WESLEY STRATTON, *Professor of Physics.*
ROBERT ANDREWS MILLIKAN, *Instructor in Physics.*
CHARLES RIBORG MANN, *Instructor in Physics.*
GLENN MOODY HOBBS, *Instructor in Physics.*
HENRY GORDON GALE, *Associate in Physics.*

OSCAR LANGE, *Mechanician.*

THE BUILDING.

The Ryerson Physical Laboratory was completed Jan. 1, 1894. In the design and construction of this building no element of utility has been omitted, and every effort was made to include all the desirable features of a first-class Physical Laboratory.

All the walls and floors are strong and heavy; the laboratories on the first floor are provided with piers of masonry, in addition to the heavy slate wall-shelves which are found throughout the building. Every laboratory is provided with gas for light or fuel, electricity for light and power, water, compressed air, and vacuum pipes.

The laboratories are also equipped with a system of heating apparatus which may be used as a direct or an indirect system, and is controlled automatically by the most improved form of temperature regulators. Ducts and channels have been provided between the walls and in the floor, so that pipes or wires may be laid from one part of the building to another without difficulty.

The space in the building has been utilized as follows: Rooms for special purposes, small laboratories for work of investigation, large laboratories for general instruction, lecture rooms, class rooms, library, and offices.

The first floor is devoted to laboratories for research work, two large constant-temperature rooms, and the mechanician's room which is fitted up with all the tools and appliances necessary in the construction and repair of physical apparatus. The rooms of the west wing are free from iron and are devoted to the work in electricity and magnetism.

On the second floor are found a large general laboratory for advanced undergraduate work, optical laboratories, a chemical laboratory, a large dark room, two developing rooms, and the large lecture hall with its adjoining apparatus and preparation rooms. The offices of the Director and faculty are also on this floor.

The third floor is devoted to a general laboratory for the undergraduate work in general physics, which with its adjoining apparatus and preparation rooms occupies the entire third floor of the east wing. On the same floor are found two general laboratories and class rooms.

The central part of the fourth floor forms a hall for experiments requiring a large space. The roof above this portion is flat and suitable for observations in the open air.

A shaft has also been provided for pressure-gauges and for experiments requiring a greater vertical distance than is found in the laboratories.

Recent investigations have shown that the location of the Ryerson Laboratory is an exceedingly good one, and that the outside disturbances which are usually so annoying are at a minimum.

XX. THE DEPARTMENT OF CHEMISTRY.

OFFICERS OF INSTRUCTION.

JOHN ULRIC NEF, PH.D., *Professor and Head of the Department of Chemistry.*
ALEXANDER SMITH, PH.D., *Associate Professor of General Chemistry.*
FELIX LENGFELD, PH.D., *Assistant Professor of Inorganic Chemistry.*
JULIUS STIEGLITZ, PH.D., *Assistant Professor of Chemistry.*
JOHN C. HESSLER, PH.D., *Instructor in Chemistry.*
LAUDER W. JONES, PH.D., *Associate in Chemistry.*
HARRY CHALMERS BIDDLE, PH.D., *Assistant in General Chemistry.*
WILLIS B. HOLMES, PH.D., *Laboratory Assistant.*
SOLOMON FARLEY ACREE, S.M., *Laboratory Assistant.* (Autumn Quarter, 1900.)

JACOBUS HENRICUS VAN 'T HOFF, PH.D., *Professor Ordinarius Honorarius in the University of Berlin.* (Summer Quarter, 1901.)
HERBERT NEWBY McCOY, PH.D., *Assistant Professor of Chemistry, University of Utah,* Salt Lake City, Utah. (Summer Quarter, 1901.)

FELLOWS.

1901-1902.

WILLIAM McAFEE BRUCE, A.M.
FRANCIS WILLIAM BUSHONG, A.M.
JOHN WILKES SHEPHERD, A.M.
WALLACE APPLETON BEATTY, S.M., *Loewenthal Fellow.*

INTRODUCTORY.

The lecture and laboratory instruction will be adapted to the wants of beginners as well as the most advanced students. Lectures will be given regularly on General Chemistry, Analytical Chemistry, Theoretical and Physical Chemistry, and advanced Inorganic and Organic Chemistry. Special courses on selected topics will also be given, which will vary from year to year. The chief instruction in every course will, however, be given in the laboratory, as far as the nature of the subject will admit. Only in exceptional cases will students be allowed to hear lectures without taking the corresponding laboratory course. Special stress will be placed on thorough preparation and symmetrical development of the student's knowledge. The object of the courses will be not so much to train specialists as to prepare the student to undertake intelligibly any and every kind of work of a chemical nature. They will, therefore, at present be adapted rather to those looking forward to a career as scientists or teachers ; yet it is unquestionable that those intending to become practical chemists will find a thorough course of purely scientific chemistry the best basis for future specialization in any direction whatever. Those who incline towards inorganic chemistry will, therefore, be required to do a considerable amount of organic work, and those proposing to become organic chemists will be required to do work in inorganic chemistry of a more advanced nature than that given in the elementary and analytical courses. (For description of the Kent Chemical Laboratory see page 14 of this PROGRAMME.)

RESEARCH WORK.

Students offering themselves as candidates for the degree of Doctor of Philosophy must not only observe the general rules of the University in regard to this degree, but must also satisfy the instructors in the different chemical branches that their previous training has been a broad one, and no degree of proficiency in a special branch will be accepted as the equivalent of this. The candidates will at once undertake research, either in Inorganic, Organic, or Physical Chemistry, under the supervision of one of the instructors or docents. The degree will be conferred only after presenting a thesis embodying the results of a satisfactory amount of work which must be a real contribution to knowledge, and after passing an examination on the general field of chemistry, as well as examinations on one or more secondary, but allied, subjects.

INDEPENDENT WORK.

Special opportunities to pursue entirely independent research work will be given to maturer students who have already obtained the doctor's degree. After completion of a sufficient amount of creditable work, and presentation of a thesis embodying the results obtained, such students may be admitted as *docents*, thereby receiving the right to lecture, give laboratory instruction, and supervise research work in the Chemical Department of the University. Students of this class, as well as others, intending to engage in independent research, are requested to make known their special requirements as early as possible, in order that the requisite materials, which are not always accessible in America, may be obtained without delay.

SPECIAL STUDENTS.

Special students, not candidates for a degree, will be received, and will be given every possible facility, but in every case they will be required to give evidence, satisfactory to the instructors in the different branches, that their previous training has been sufficient, both in latitude and amount, to enable them to derive full profit from the courses they propose to take.

SEMINAR WORK.

A Chemical Seminar will be held, usually bi-weekly, in which all advanced students will take part, and in which recent chemical work will be presented and discussed, and informal lectures given on various topics of interest to chemists.

PREREQUISITES.

A good reading knowledge of French and German is desirable for Courses 9–17, and will be required for Courses 18–42.

FELLOWSHIPS.

University fellowships yielding an income of $320 or $520 annually are open to graduate students in chemistry. A fellowship in Chemistry has been endowed since 1901 by Mr. Berthold Loewenthal of Chicago as a memorial of his son, Joseph B. Loewenthal; it yields an annual income of $420. The appointments to these fellowships will be based exclusively on merit. A fellow will be expected to render assistance to the department in serving as an assistant at lectures or in the laboratory. In no case however, will he be required, or allowed, to devote more than one-sixth of his time to such service.

PUBLICATIONS.

The scientific work carried out in the laboratory will be published in various existing periodicals as "Contributions from the Kent Chemical Laboratory of The University of Chicago." Owing to the fact that a journal devoted to pure scientific work in chemistry already exists in the country, it is deemed unnecessary to edit a departmental journal.

LIBRARY FACILITIES.

The department is equipped with an almost complete list of periodicals, past and current, necessary for prosecuting research; it also possesses a large number of reference and handbooks.

A number of general scientific journals and many of the proceedings of learned societies are received in the General Library.

COURSES OF INSTRUCTION.

Summer Quarter, 1901—Spring Quarter, 1902.

M=Minor course=a single course for six weeks. DM=Double Minor course=a double course (two hours daily) for six weeks. Mj=Major course=a single course for twelve weeks. DMj=Double Major course=double course for twelve weeks.

Professor Van't Hoff, of the University of Berlin, will offer a limited number of lectures on Physical Chemistry during the Summer Quarter.

Primarily for the Junior Colleges.

1, 2, 3. **General Inorganic Chemistry.**—*Elementary Course.*
Class room 3 hrs. a week, 12:00.
Laboratory 6 hrs. a week.
3Mjs. Autumn and Winter Quarters.
Associate Professor Smith.
Spring Quarter.
Assistant Professor Lengfeld.

This is a continuous course through three quarters.

The lectures and class-room work of 1, 2, and 3 may be taken by Graduate Students without the laboratory work or laboratory fee.

4. **General Inorganic Chemistry.**—*Elementary Course.*
DMj. Summer Quarter.
Lectures 6 hrs. a week; 10:30.
Laboratory work 12 hrs. a week; 2:00–5:00.
Assistant Professor Lengfeld.

The lectures and class-room work of 4 may be taken by Graduate Students without the laboratory work or laboratory fee.

Students offering entrance chemistry do more advanced laboratory work than those not offering it.

Courses 1 and 4 must be preceded by Preparatory (entrance) Physics or its equivalent, including some laboratory work.

The aim of the equivalent continuous Courses 1, 2, 3, and of 4 will be to give a definite idea of the fundamental principles of chemistry, and not to overburden the student with a mass of unconnected facts. The lectures will be experimental to a considerable extent. The course is designed to meet the wants not only of those who wish to go deeper into chemistry, but of all who wish to secure a liberal education.

1B, 2B. **General Inorganic Chemistry.**—*Special Course.*—2Mjs. Autumn and Winter Quarters.
Class room 3 hrs. a week, 8:30.
Laboratory 6 hrs. a week.
Assistant Professor Lengfeld.
Prerequisite: *Entrance Chemistry and Physics, 1 unit each.*

1B and 2B, preceded by 1 unit entrance chemistry, are equivalent to the continuous 3Mj course. This is a special course designed to form a sequel to high-school chemistry. The lecture, laboratory, and recitation work are all distinct from that of Courses 1 and 2. Whenever the preparation justifies it, qualitative analysis (Course 6) may be substituted for 2B.

Note.—Two hours of laboratory are reckoned as equal to one hour of lecture work.

5. **Organic Chemistry.**—*Elementary Course.*
Class room 3 hrs. a week (M), 2:00.
Laboratory work 6 hrs. a week (M).
Mj. Spring Quarter.
Dr. Jones.
Prerequisite: *General Chemistry.*

The lectures may be taken without laboratory work as a Minor.

Primarily for the Senior Colleges.

Note.—Courses 6, 7, 8, 9, 10, 11, and 13 are given in the analytical laboratories. The laboratories are open from 8:00 a.m to 6:00 p.m. (Saturdays only to 1:00 p.m.) In the Autumn, Winter, and Spring Quarters, the *hours for instruction* in the laboratories are 2:00 to 5:30 p.m. Mondays to Thursdays, and 9:00 a.m. to 12:30 p.m. Fridays and Saturdays. Students are obliged to take at least two thirds of the required laboratory work in the time allotted to instruction, and are required *to register for definite laboratory hours* on registering for a course in analytical chemistry.

6, 7. **Qualitative Analysis.**—Chiefly laboratory work.
2 Mjs. or 2DMs. 8 or 16 hrs. a week laboratory.
2 hrs. a week class room. Lectures: 2:00.
Summer Quarter.
Assistant Professor Stieglitz
and Dr. Hessler.
Autumn, Winter, and Spring Quarters.
Assistant Professor Stieglitz
and Dr. Jones.
Prerequisite: *Courses 1, 2, 3,* or *4,* or *1B and 2B.*

Courses 6, 7, 8 form a continuous course, which may be begun in any quarter.

The aim in Courses 6, 7, 8 will be to train the student to do intelligent analytical work and to enable him to analyze, at the end of the course, any mixture containing common inorganic compounds.

9, 10. **Quantitative Analysis.** — Chiefly laboratory work in volumetric and gravimetric analysis.
2Mjs or 2DMs. 10 or 20 hrs. a week.
Summer Quarter.
Assistant Professor Stieglitz
and Dr. McCoy.
Autumn, Winter, and Spring Quarters.
Assistant Professor Stieglitz.
(Dr. Jones assisting in the Laboratory.)

Prerequisite: *Qualitative Analysis.*

Courses 9, 10, 11 form a continuous course, which may be begun in any quarter.

Primarily for the Graduate School.

8 **Advanced Qualitative Analysis.**—Mj. or DM. 10 or 20 hrs. a week, laboratory. Summer Quarter.
Assistant Professor Stieglitz
and Dr. McCoy.
Autumn, Winter, and Spring Quarters.
Assistant Professor Stieglitz
and Dr. Jones.

Open to College students. Continuation of Courses 6 and 7

11. **Advanced Quantitative Analysis.**—Mj or DM. 10 or 20 hrs. a week. Summer Quarter.
Assistant Professor Stieglitz
and Dr. McCoy.
Autumn, Winter, and Spring Quarters.
Assistant Professor Stieglitz.
(Dr. Jones assisting in the Laboratory.)

Continuation of Courses 6 and 10. Open to students in the Senior Colleges.

12. **Elementary Spectrum Analysis (Qualitative).** — Emission (flame and electric spark) and absorption spectra of inorganic substances. Chiefly laboratory work. ½Mj. Winter Quarter.
Dr. Jones.

13. **Special Methods in Quantitative Analysis.**—Special analysis of water, ores, minerals, etc.; gas analysis; analysis by electrolytic methods. Chiefly laboratory work.
Summer, Winter and Spring Quarters.
Assistant Professor Stieglitz.

Prerequisite: *Quantitative Analysis.*

Candidates for the degree of Ph.D. intending to pursue research work in Inorganic Chemistry will be required to take 2DMs or 2Mjs of this course; those intending to pursue research work in Organic Chemistry will be required to take one DM or Mj.

14, 15, 16. **Organic Chemistry.**—The compounds of carbon, including the fatty and the aromatic series. The aim of the course will be to take up very thoroughly the simpler compounds, going with great detail into the chemical behavior, the characteristic reactions and relationships of the different classes of organic compounds, and considering the synthetic methods by which they can be obtained, with great care. Richter's or Bernthsen's *Organic Chemistry* is used as a reference book, but recent literature will, in special cases, be considered in detail. Lectures.
3Mjs. Autumn and Winter Quarters, and First Term of Spring Quarter; 12:00.
Professor Nef.

Prerequisite: *General Chemistry and Qualitative Analysis.*

17. **General Organic Chemistry.**—Fatty and aromatic series.
Lectures, 5 hrs. a week.
Mj. Summer Quarter; 8:30.
Dr. Jones.

Prerequisite: *General Chemistry and Qualitative analysis.*

18. **Elementary Organic Preparations.**—Laboratory work; 10 hrs. a week. This course is arranged to accompany the lectures of Course 17. It may be taken without the lectures.
Mj. Summer Quarter.
Dr. Jones.

Prerequisite: *As in Course 17.*

20, 21, 22. **Organic Preparations.** — Laboratory work, 10 or 20 hrs. a week. Each course Mj or DM.
Autumn, Winter, and Spring Quarters.
Professor Nef.
Summer Quarter.
Dr. Jones.

Prerequisite: *Qualitative and Quantitative Analysis, Mineralogy* (for candidates for the degree of Ph.D.), and *Organic Chemistry* (it may be taken simultaneously in connection with lectures on Organic Chemistry). Those intending to pursue research work in Inorganic Chemistry will be required to take 2DMs of this course and those intending to pursue research work in Organic Chemistry will be required to take the 3DMs. A reading knowledge of French and German is essential.

23. **Advanced General Chemistry.** — Causes of and conditions for chemical action. 4 hrs. a week.
Mj. Spring Quarter; 8:30.
ASSOCIATE PROFESSOR SMITH.

Prerequisite: *College Physics, General Chemistry, and Qualitative Analysis.*
[Not to be given in 1902.]

24. **Advanced Inorganic Chemistry.**—Two lectures a week on selected topics. ½Mj.
Spring Quarter.
ASSISTANT PROFESSOR LENGFELD.

Prerequisite: *General Chemistry and Qualitative Analysis.*

25, 26, 27. **Inorganic Preparations.**—Laboratory work. Each course Mj or DM. 10 or 20 hrs. a week. Summer, Autumn, Winter, and Spring Quarters.
ASSISTANT PROFESSOR LENGFELD.

Prerequisite: *Qualitative and Quantitative Analysis, and a reading knowledge of French and German.*

Those intending to pursue research work in Organic Chemistry will be required to take 2DMs of this course; those intending to engage in Inorganic Research will be required to take 3DMs.

31, 32. **Theoretical Chemistry.**—With special reference to physical methods.
2Ms. Winter and Spring Quarters.
2 hrs. a week.
ASSISTANT PROFESSOR LENGFELD.

Prerequisite: *College Physics and General Chemistry.*

31A. **Theoretical Chemistry.**—With special reference to physical methods. 4 hrs. a week.
M. First Term, Summer Quarter; 8:30.
ASSISTANT PROFESSOR LENGFELD.

Prerequisite: *College Physics and General Chemistry.*
[Not to be given in 1901–2.]

33. **Research Work for Ph.D. Thesis.**—This course will include from 30 to 40 hrs. a week of laboratory work, under the special direction of some one of the instructors in the department. It is expected that a student will be occupied for a period of 4–8 quarters, 4–8 DMjs.

33*a*. RESEARCH IN ORGANIC CHEMISTRY. — Autumn, Winter, and Spring Quarters.
PROFESSOR NEF.
Summer Quarter.
DR. HESSLER.

33*b*. RESEARCH IN GENERAL CHEMISTRY. — Autumn, Winter, and Spring Quarters.
ASSOCIATE PROFESSOR SMITH.

33*c*. RESEARCH IN INORGANIC CHEMISTRY. — Summer, Autumn, Winter, and Spring Quarters.
ASSISTANT PROFESSOR LENGFELD.

33*d*. RESEARCH IN ORGANIC CHEMISTRY. — Summer, Autumn, Winter, and Spring Quarters.
ASSISTANT PROFESSOR STIEGLITZ.

Before being admitted to Research, a candidate must satisfy the instructors of the department, by an oral test, or otherwise, that his or her previous training has been sufficient.

A candidate for the degree of Ph.D. must have taken Courses 1, 2, 3 (or 4), (or 1*B*, 2*B*) 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 31, 32; the amount required of Courses 18, 19, 20 and 25, 26, 27; as well as at least eight ½Mj among the special Courses 12, 23, 24, 34, 35, 36, 37, 38, 39, 40, 41, 42, or their equivalent.

34. **Physico-Chemical Methods.** — Determination of specific gravity, molecular weights, etc. Laboratory work, 5 hrs. a week for one term.
½Mj. Spring Quarter.
ASSISTANT PROFESSOR LENGFELD.

35. **The Carbohydrates and the Terpenes** (and their derivatives).
Lectures, 2 hrs. a week.
½Mj. Summer Quarter.
ASSISTANT PROFESSOR STIEGLITZ.

Prerequisite: *Organic Chemistry.*

36. **Organic Nitrogen Derivatives.**—Uric acid series; pyridine, quinone-imides, and phenazine compounds; a discussion of the alkaloids, ptomaines, and organic dye-stuffs.
Lectures, 2 hrs. a week.
½Mj. Winter Quarter.
ASSISTANT PROFESSOR STIEGLITZ.

Prerequisite: *Organic Chemistry.*
[Not to be given in 1901–2.]

37. **Special Chapters of Organic Chemistry.**— Lectures, 4 hrs. a week.
M. Second Term, Spring Quarter; 12:00.
PROFESSOR NEF.

Prerequisite: *Organic Chemistry.*

38, 39. **The Aromatic Series.** — Lectures, 2 hrs. a week. Two ½Mjs.

Autumn and Winter Quarters.

ASSISTANT PROFESSOR STIEGLITZ.

Prerequisite: *Organic Chemistry.*

42. **History of Chemistry.** — 2 hrs. a week. Winter and Spring Quarters. Two ½Mjs.

[Not to be given in 1902.]

43. **Journal Meetings.**

Autumn and Winter Quarters.

PROFESSOR NEF.

All candidates for the degree of Ph.D., more advanced students, will be present, and take part in turn in presenting and discussing recent investigations. Meetings will be held on alternate Fridays from 5:00 to 6:00. They may be attended by anyone interested, whether connected with the University or not; the subjects for the meetings will be announced at least one week beforehand.

THE KENT CHEMICAL LABORATORY.

OFFICERS OF GOVERNMENT.

JOHN ULRIC NEF, *Professor of Chemistry, and Director.*
ALEXANDER SMITH, *Associate Professor of General Chemistry.*
FELIX LENGFELD, *Assistant Professor of Inorganic Chemistry.*
JULIUS STIEGLITZ, *Assistant Professor of Chemistry.*
JOHN C. HESSLER, *Instructor in Chemistry.*
LAUDER W. JONES, *Associate in Chemistry.*
HARRY CHALMERS BIDDLE, *Assistant in General Chemistry.*
WILLIS B. HOLMES, *Laboratory Assistant.*

THE BUILDING.

The Chemical Laboratory, provided by the generosity of Mr. Sidney A. Kent, was opened January 1, 1894.

The rooms are arranged as follows:

The *basement* contains a furnace room, with a set of gas furnaces, with air blast of the most modern construction, for crucible work, muffle work, tube heating, and other purposes; a constant temperature room, a room fitted with steam and other appliances for work on a large scale, a mechanical workshop, and storage rooms.

On the *first floor* are one small and two large lecture rooms, and a large lecture hall seating three hundred persons, fitted for use as a chemical lecture room, if desired. This floor also contains a chemical museum, a large private laboratory, a room with northern exposure, especially fitted for use as a gas analysis laboratory, and also apparatus and preparation rooms connected with the lecture rooms.

On the *second floor* are two large laboratories intended for research and advanced work, three private laboratories for the professors, balance, combustion air furnace, and storerooms, a balcony for out-of-door work, and the chemical library, which contains full sets of the most important journals, as well as the most important text-books and other works, relating to chemistry.

On the *third floor* are three large laboratories for general and analytical chemistry, a storeroom, a preparation room, a room especially fitted for optical and photographic work, a balance room, and a private laboratory. The most modern system of ventilation has been adopted, air of constant temperature being forced in by fans from below, and withdrawn by a fan above. The building will be lighted throughout by electric lights, and the laboratories will be provided with electricity adapted to every kind of electro-chemical work.

The fullest opportunity will be given for doing research work. All possible aid will be afforded those who desire to avail themselves of the facilities of the laboratory.

The University will be glad to answer inquiries from institutions looking for well-equipped teachers in Physics and Chemistry.

Letters of inquiry and requests for documents should be addressed to

THE UNIVERSITY OF CHICAGO,
Chicago, Ill.

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PROGRAMME

OF THE DEPARTMENTS OF

PHYSICS AND CHEMISTRY

1902-1903

CHICAGO
The University of Chicago Press
1902

XIX. THE DEPARTMENT OF PHYSICS.

OFFICERS OF INSTRUCTION.

ALBERT ABRAHAM MICHELSON, Ph.D., Sc.D., LL.D., *Professor and Head of the Department of Physics.*
SAMUEL WESLEY STRATTON, S.B., *Professor of Physics.*
CHARLES RIBORG MANN, Ph.D., *Assistant Professor of Physics.*
ROBERT A. MILLIKAN, Ph.D., *Assistant Professor of Physics.*
GLENN MOODY HOBBS, S.B., *Instructor in Physics.*
HENRY GORDON GALE, Ph.D., *Instructor in Physics.*
FRANK BALDWIN JEWETT, A.B., *Research Assistant in Physics.*

FELLOWS.

1902-1903.

FANNIE CORNELIA FRISBIE, A.B.
FRANK HOWARD WESCOTT, A.B.
CHARLES ALBERT PROCTOR, A.B.

OSCAR LANGE, *Mechanician.*
JULIUS PEARSON, *Assistant Mechanician.*

INTRODUCTORY.

Within the last twenty years the teaching and practice of Physics has undergone a revolution more complete than that of any of its sister sciences. This result may be attributed, to a very great extent, to the enormous development of its applications to electrical industries. No other industrial application since the invention of the steam-engine has so enhanced the appreciation of the importance of exact knowledge, or given a greater impetus to the search for new truths in the unexplored regions on the borderland of science.

So closely interwoven are the advances in pure science and its applications that it is difficult to say which has been of greater service to the other, but it is evident that it is as ill-advised to ignore the powerful stimulus furnished by the practical development of scientific ideas as it is to belittle the influence which theoretical and experimental science have had on the world's material prosperity.

While it is never safe to affirm that the future of Physical Science has no marvels in store even more astonishing than those of the past, it seems probable that most of the grand underlying principles have been firmly established, and that further advances are to be sought chiefly in the rigorous application of these principles to all the phenomena which come under our notice.

It is here that the science of measurement shows its importance—where quantitative results are more to be desired than qualitative work. An eminent physicist has remarked that the future truths of Physical Science are to be looked for in the sixth place of decimals.

In order to make such work possible, the student and investigator must have at his disposal the methods and results of his predecessors, must know how to gauge them, and to apply them to his own work; and especially must he have at his command all the modern appliances and instruments of precision which constitute a well-equipped laboratory—without which results of real value can be obtained only at immense sacrifice of time and labor.

The science of Astronomy appeals far more powerfully to most people than does Physical Science, which, indeed, to many is scarcely known even by name. The former is as old as history. Its wonders have compelled the attention of mankind from the earliest ages, and it is but a natural consequence that at the present day no important city in the civilized world is without a richly endowed observatory, where a trained corps of astronomers are able to study the phenomena of the life of suns and worlds, and their distribution in time and space,

It is only in very recent times that it has begun to dawn upon the mind of man that there is another world only one degree less complex and wonderful than the stellar universe — the world of molecules and atoms. For the study of these almost infinitesimal systems of pigmy stars we have no telescope nor even microscope to help us; but little by little we are constructing a powerful logical engine which is destined one day to bring the revolutions, rotations, and oscillations of these minute orbs as clearly to the mind's eye as are now the motions of the worlds of the greater, visible universe.

It may be said that this is, in fact, our chief problem—the constitution of matter; and while ultimately this is, and must always be, beyond the scope of our powers, it is as legitimate and worthy an object to extend our knowledge step by step in this direction as to increase our knowledge of the structure of the sidereal universe, even though this can never be completely fathomed.

As in the case of Astronomical observatories the work, while chiefly devoted to furthering the interests of pure science, is nevertheless consistent with the furnishing of valuable information of immediate practical utility, so a Research Laboratory, while carefully preserving its chief and essential feature, may be still practically useful in furnishing authoritative measurements of standards of length, mass, and time, calibration of thermometers, pressure-gauges, comparison of standards, of resistance, electro-motive force, capacity, self-induction, etc.

It is hoped that this outline of the aims and ends of a Physical Research Laboratory, partial and incomplete though it be, may justify the hope and belief that the generosity of the founder of the University and the donor of the Ryerson Physical Laboratory will be supplemented by many other liberally minded men, equally disposed to further so worthy a cause.

In the enthusiasm which inevitably accompanies the work of the investigator, that of the instructor will not be ignored; indeed, it is confidently expected that these two functions will mutually assist each other.

The courses of instruction to be given in the Department of Physics, it is believed, are sufficiently varied to suit the requirements of all classes, including those who desire simply to complete a general education, or to undertake the subject as a disciplinary study; those who wish to pursue it as a preliminary to its application to mechanical, electrical, or civil engineering; or those who intend to make it their life-work.

In each case every opportunity will be taken to present the subject in such a way as to impress the student with the reality of the principles and laws expounded by well-chosen experiments, performed by the instructor, and whenever possible by the student himself.

A feature on which considerable stress will be laid is the repetition of the classical experiments of eminent investigators by those graduate students who are able to undertake them.

It is believed that by this means a great deal of valuable experience will be gained, without the vexatious annoyances encountered in entering upon an original investigation, before having the benefit of such preliminary training.

For a description of the Ryerson Physical Laboratory, see p. 7 of this Programme.

FELLOWSHIPS AND GRADUATE SCHOLARSHIPS.

The University appoints each year a limited number of fellowships and graduate scholarships. Detailed information concerning these and the conditions of their appointment may be obtained by communicating with the University of Chicago.

COURSES OF INSTRUCTION.

Summer Quarter, 1902—Spring Quarter, 1903.

M=Minor course=a single course for six weeks. DM=Double Minor course=a double course (two hours daily) for six weeks. Mj=Major course=a single course for twelve weeks. DMj=Double Major course=a double course (two exercises daily) for twelve weeks.

Junior College Courses.

0. **Elementary Physics.** — A first course in the elements of Physics. (See prerequisite to Course 1.)
Mj. Autumn Quarter, 9:30.
Dr. Gale.
Continued. Mj. Winter Quarter, 9:30.
Mr. Hobbs.

1. **General Physics.**—A course in General Physics in which are presented mainly from the experimental standpoint the most important principles involved in the study of mechanics, properties of liquids and gases, heat and sound.
10 hrs. a week. Mj. Each quarter.
Summer Quarter; 8:30–10:30.
Mr. Hobbs.
11:00–1:00.
Dr. Gale.
Repeated. Mj. Autumn Quarter; 8:30–10:30; 11:00–1:00.
Mr. Hobbs.
Repeated. Mj. Winter Quarter; 11:00–1:00.
Mr. Hobbs.
Repeated. Mj. Spring Quarter; 8:30–10:30.
Dr. Gale.

Prerequisite: *Entrance Physics*, or *both Majors of Course 0 and Plane Trigonometry.*

2. **General Physics.**—A continuation of Course 1 covering the subjects of electricity and light.

10 hrs. a week. Mj. Summer Quarter; 2:00–4:00. MR. HOBBS AND MR. JEWETT.

Repeated. Mj. Winter Quarter, 8:30–10:30. ASSISTANT PROFESSOR MILLIKAN.

Prerequisite: *General Physics 1.*

3. **General Physics.**—A course of lectures and demonstrations intended to complete a year's work in Junior College Physics. The most important principles of Physics not treated in Courses 1 and 2 are presented from the lecture standpoint.

5 hrs. a week. Mj. Spring Quarter; 9:30. ASSISTANT PROFESSOR MILLIKAN, with occasional lectures by PROFESSOR MICHELSON.

Repeated. Mj. Summer Quarter; 9:30. ASSISTANT PROFESSOR MANN.

Prerequisite: *General Physics 1.*

SENIOR COLLEGE COURSES.

11. **Molecular Physics.**—A lecture course for advanced and graduate students, covering the Kinetic Theory of Gases, Capillarity, Solution, and the Ionic Theory of Galvanic Action.

Mj. Winter Quarter; 11:00. ASSISTANT PROFESSOR MILLIKAN.

Prerequisite: *General Physics, 1, 2, and 3, Differential and Integral Calculus.*

12. **Sound and Light.**—A lecture course for advanced and graduate students covering the subjects of sound, music and the more important sections of geometrical and physical optics.

5 hrs. a week. Mj. Autumn Quarter; 11:00. ASSISTANT PROFESSOR MANN.

Prerequisite: *Differential and Integral Calculus, Physics 1, 2, and 3.*

13. **Electricity and Magnetism.** — A course of advanced work in theoretical Electricity and Magnetism, intended to supplement the work in General Physics or prepare for the graduate work.

5 hrs. a week. Mj. Spring Quarter; 12:00. PROFESSOR MICHELSON.

Prerequisite: *Differential and Integral Calculus, Physics 1, 2, and 3.*

16. **Experimental Physics** (Advanced).—*Fundamental Measurements.* — A course consisting of the better class of measurements of mass, length, and time, the determination of the constants of elasticity, molecular physics and heat.

10 hrs. a week. Mj. Winter Quarter; 2:00–4:00. ASSISTANT PROFESSOR MILLIKAN AND MR. HOBBS.

Prerequisite: *Differential and Integral Calculus, Physics 1, 2, and 3.*

17. **Experimental Physics** (Advanced). — *Light.* — A course of advanced laboratory work in Light, consisting of accurate measurements in diffraction, dispersion, interference, and polarization.

10 hrs. a week. Mj. Autumn Quarter; 2:00–4:00. ASSISTANT PROFESSOR MANN.

Prerequisite: *Differential and Integral Calculus, Physics 1, 2, and 3.*

18. **Experimental Physics** (Advanced). — *Electricity and Magnetism.*—Laboratory work of the same grade as Courses 16 and 17, but consisting of measurements in Electricity and Magnetism.

10 hrs. a week. Mj. Spring Quarter; 2:00–4:00. ASSISTANT PROFESSOR MILLIKAN.

Prerequisite: *Differential and Integral Calculus, Physics 1, 2, and 3.*

19A. **Experimental Physics** (Advanced). — Students registering for this course are permitted to select such problems from Courses 16, 17, and 18, as they desire, subject to the approval of the instructor.

10 hrs. a week. Mj. Summer Quarter; 10:30–12:30. ASSISTANT PROFESSOR MANN.

19B. **Experimental Physics** (Advanced). — 10 hrs. a week. Mj. Summer Quarter; 2:00–4:00. DR. GALE.

NOTE.—Students wishing to do double work in the laboratory may register for both Courses 19A and 19B.

Prerequisite: *Physics 1, 2, and 3.*

20. **Physical Manipulation.** — A series of exercises not provided for in the regular courses of Experimental Physics, but exceedingly important to the teacher or advanced student consisting of the following groups:

Group A. *Shop Work* includes the cutting, filling, drilling, tapping, soldering, and polishing of metal, screw cutting, and elementary lathe work.

Group B. *Glass Work* includes the cutting, grinding, drilling, polishing, and testing of glass.

Group C. *Glass Blowing* includes the simpler processes in glass blowing, such as cutting, bending, and joining of tubes, blowing bulbs, sealing in electrodes, etc.

Group D. *Chemical Processes and Physical Preparations* includes the silvering of glass, cleaning and distillation of mercury, preparation of fibers for suspension, and materials useful in experimental work.

10 hrs. a week, Mj. Summer Quarter; 11:00–1:00. Mr. Hobbs.

Note. — Mr. Hobbs will be assisted, during the Summer Quarter, by specialists in Groups A, B, and C. A laboratory fee of $5.00 will be charged for this course. Groups B and C will be given in the First Term only.

Repeated. Mj. Winter Quarter; 11:00–1:00.
Assistant Professor Mann.

Prerequisite: *Physics 1, 2, and 3.*

24. **Mechanical Drawing.** — A course designed to acquaint the student with the principles of mechanical drawing and projection, the preparation of working sketches and drawings, and elementary curve tracing.

10 hrs. a week. Mj. Summer Quarter; 10:30–12:30. Mr. Jewett.

Repeated. Mj. Spring Quarter; 3:00–5:00.
Mr. Jewett.

Graduate Courses.

30, 31. **Theoretical Physics.**— A series of lectures, chiefly in Theoretical Physics. Hydrodynamics, Elasticity, Capillarity, Molecular Physics, Thermodynamics, Wave-motion and Sound. Optical Theories, Electricity and Magnetism, 4 hrs. a week.

30. Mj. Autumn Quarter; 12:00.
31. Mj. Winter Quarter; 12:00.
Professor Michelson.

Prerequisite: *Physics 11, 12 and 13.*

32. **Experimental Physics.** — A course of laboratory work, chiefly devoted to the repetition of classical experiments, such as: Determination of the Mechanical Equivalent of Heat, Maxwell's "V" Hertzian Oscillation, Relative and absolute Wave-lengths, etc.

10 hrs. a week. Mj.
Autumn, Winter, Spring Quarters.
Professor Michelson.

Prerequisite: *Physics, 16, 17, and 18.*

33. **Research Course.** — This course is intended for those graduate students who are prepared to undertake special research.

Except in the case of a purely mathematical problem, the entire time is to be devoted to work in the laboratory.

20 hrs. a week. Every Quarter.
DMj. Summer Quarter.
Assistant Professor Mann.
3DMj. Autumn, Winter, and Spring Quarters.
Professor Michelson.

36. **Thermodynamics.** — Lectures upon the fundamental principles underlying the mechanical theory of heat and the application of these principles to physical and thermochemical problems.

5 hrs. a week. Mj.
Assistant Professor Millikan.
[Not to be given in 1902–3.]

37. **Dynamics.**—Lectures.
Mj. Autumn Quarter; 11:00.
Dr. Gale.

40. **Seminar:** *History of the Development of Physical Ideas.*
2Mj. Autumn and Winter Quarters; 4:00.
Assistant Professor Mann.

THE RYERSON PHYSICAL LABORATORY.

OFFICERS OF GOVERNMENT.

ALBERT ABRAHAM MICHELSON, *Professor and Head of the Department of Physics.*
SAMUEL WESLEY STRATTON, *Professor of Physics.*
ROBERT ANDREWS MILLIKAN, *Assistant Professor of Physics.*
CHARLES RIBORG MANN, *Assistant Professor of Physics.*
GLENN MOODY HOBBS, *Instructor in Physics.*
HENRY GORDON GALE, *Instructor in Physics.*
FRANK BALDWIN JEWETT, *Research Assistant in Physics.*

OSCAR LANGE, *Instrument Maker.*
JULIUS PEARSON, *Assistant Instrument Maker.*

THE BUILDING.

The Ryerson Physical Laboratory was completed Jan. 1, 1894. In the design and construction of this building no element of utility has been omitted, and every effort was made to include all the desirable features of a first-class Physical Laboratory.

All the walls and floors are strong and heavy; the laboratories on the first floor are provided with piers of masonry, in addition to the heavy slate wall-shelves which are found throughout the building. Every laboratory is provided with gas for light or fuel, electricity for light and power, water, compressed air, and vacuum pipes.

The laboratories are also equipped with a system of heating apparatus which may be used as a direct or an indirect system, and is controlled automatically by the most improved form of temperature regulators. Ducts and channels have been provided between the walls and in the floor, so that pipes or wires may be laid from one part of the building to another without difficulty.

The space in the building has been utilized as follows: Rooms for special purposes, small laboratories for work of investigation, large laboratories for general instruction, lecture rooms, class rooms, library, and offices.

The first floor is devoted to laboratories for research work, two large constant-temperature rooms, and the mechanician's room which is fitted up with all the tools and appliances necessary in the construction and repair of physical apparatus. The rooms of the west wing are free from iron and are devoted to the work in electricity and magnetism.

On the second floor are found a large general laboratory for advanced undergraduate work, optical laboratories, a chemical laboratory, a large dark room, two developing rooms, and the large lecture hall with its adjoining apparatus and preparation rooms. The offices of the Director and of the faculty are also on this floor.

The third floor is devoted to a general laboratory for the undergraduate work in general physics, which with its adjoining apparatus and preparation rooms occupies the entire floor of the east wing. On the same floor are found two general laboratories and class rooms.

The central part of the fourth floor forms a hall for experiments requiring a large space. The roof above this portion is flat and suitable for observations in the open air.

A shaft has also been provided for pressure-gauges and for experiments requiring a greater vertical distance than is found in the laboratories.

Recent investigations have shown that the location of the Ryerson Laboratory is an exceedingly good one, and that the outside disturbances which are usually so annoying are at a minimum.

XX. THE DEPARTMENT OF CHEMISTRY.

OFFICERS OF INSTRUCTION.

JOHN ULRIC NEF, PH.D., *Professor and Head of the Department of Chemistry.*
ALEXANDER SMITH, PH.D., *Associate Professor of General Chemistry.*
JULIUS STIEGLITZ, PH.D., *Associate Professor of Chemistry.*
JOHN C. HESSLER, PH.D., *Instructor in Chemistry.*
HERBERT NEWBY McCOY, PH.D., *Instructor in Chemistry.*
LAUDER W. JONES, PH.D., *Instructor in Analytical Chemistry.*
WILLIS B. HOLMES, PH.D., *Research Assistant in Chemistry.*
IRA M. DERBY, S.B., *Research Assistant in Chemistry.*
ROY HUTCHISON BROWNLEE, A.B., *Lecture Assistant.*
THOMAS B. FREAS, A.B., *Laboratory Inspector.*
JOHN W. SHEPHERD, A.M., *Assistant in Quantitative Analysis.*

WALTER STANLEY HAINES, A.M., M.D., *Professor of Chemistry, Pharmacy, and Toxicology, Rush Medical College; Professorial Lecturer on Toxicology.*

FELLOWS.

1902-1903.

RAYMOND BACON, S.B, A.M.
WILLIAM McAFEE BRUCE, A.M.
WALLACE APPLETON BEATTY, S.M., *Loewenthal Fellow.*
ALFRED OGLE SHAKLEE, S. B.

INTRODUCTORY.

The lecture and laboratory instruction will be adapted to the wants of beginners as well as the most advanced students. Lectures will be given regularly on General Chemistry, Analytical Chemistry, Theoretical and Physical Chemistry, and advanced Inorganic and Organic Chemistry. Special courses on selected topics will also be given, which will vary from year to year. The chief instruction in every course will, however, be given in the laboratory, as far as the nature of the subject will admit. Only in exceptional cases will students be allowed to hear lectures without taking the corresponding laboratory course. Special stress will be placed on thorough preparation and symmetrical development of the student's knowledge. The object of the courses will be not so much to train specialists as to prepare the student to undertake intelligibly any and every kind of work of a chemical nature. They will, therefore, at present be adapted rather to those looking forward to a career as scientists or teachers ; yet it is unquestionable that those intending to become practical chemists will find a thorough course of purely scientific chemistry the best basis for future specialization in any direction whatever. Those who incline towards inorganic chemistry will, therefore, be required to do a considerable amount of organic work, and those proposing to become organic chemists will be required to do work in inorganic chemistry of a more advanced nature than that given in the elementary and analytical courses. (For description of the Kent Chemical Laboratory see page 14 of this PROGRAMME.)

RESEARCH WORK.

Students offering themselves as candidates for the degree of Doctor of Philosophy must not only observe the general rules of the University in regard to this degree, but must also satisfy the instructors in the different chemical branches that their previous training has been a broad one, and no degree of proficiency in a special branch will be accepted as the equivalent of this. The candidates will at once undertake research, either in Inorganic, Organic, or Physical Chemistry, under the supervision of one of the instructors or docents. The degree will be conferred only after presenting a thesis embodying the results of a satisfactory amount of work which must be a real contribution to knowledge, and after passing an examination on the general field of chemistry, as well as examinations on one or more secondary, but allied, subjects.

INDEPENDENT WORK.

Special opportunities to pursue entirely independent research work will be given to maturer students who have already obtained the doctor's degree. After completion of a sufficient amount of creditable work, and presentation of a thesis embodying the results obtained, such students may be admitted as *docents*, thereby receiving the right to lecture, give laboratory instruction, and supervise research work in the Chemical Department of the University. Students of this class, as well as others, intending to engage in independent research, are requested to make known their special requirements as early as possible, in order that the requisite materials, which are not always accessible in America, may be obtained without delay.

SPECIAL STUDENTS.

Special students, not candidates for a degree, will be received, and will be given every possible facility, but in every case they will be required to give evidence, satisfactory to the instructors in the different branches, that their previous training has been sufficient, both in latitude and amount, to enable them to derive full profit from the courses they propose to take.

SEMINAR WORK.

A Chemical Seminar will be held, usually bi-weekly, in which all advanced students will take part, and in which recent chemical work will be presented and discussed, and informal lectures given on various topics of interest to chemists.

PREREQUISITES.

A good reading knowledge of French and German is desirable for Courses 9–17, and will be required for Courses 18–42.

FELLOWSHIPS.

University fellowships yielding an income of $320 or $520 annually are open to graduate students in chemistry. A fellowship in Chemistry has been endowed since 1901 by Mr. Berthold Loewenthal of Chicago as a memorial of his son, Joseph B. Loewenthal; it yields an annual income of $420. The appointments to these fellowships will be based exclusively on merit. A fellow will be expected to render assistance to the department in serving as an assistant at lectures or in the laboratory. In no case however, will he be required, or allowed, to devote more than one sixth of his time to such service.

PUBLICATIONS.

The scientific work carried out in the laboratory will be published in various existing periodicals as "Contributions from the Kent Chemical Laboratory of the University of Chicago." Owing to the fact that a journal devoted to pure scientific work in chemistry already exists in the country, it is deemed unnecessary to edit a departmental journal.

LIBRARY FACILITIES.

The department is equipped with an almost complete list of periodicals, past and current, necessary for prosecuting research; it also possesses a large number of reference and handbooks.

A number of general scientific journals and many of the proceedings of learned societies are received in the General Library.

COURSES OF INSTRUCTION.

Summer Quarter, 1902 — Spring Quarter, 1903.

M=Minor course=a single course for six weeks. DM=Double Minor course=a double course (two hours daily) for six weeks. Mj=Major course=a single course for twelve weeks. DMj=Double Major course=double course for twelve weeks.

PRIMARILY FOR THE JUNIOR COLLEGES.

1, **General Inorganic Chemistry.**—*Elementary Course.*
Class room 3 hrs. a week, 12:00.
Laboratory 6 hrs. a week.
Mj. Autumn Quarter.
ASSOCIATE PROFESSOR SMITH.

2. **General Inorganic Chemistry.** — Continuation of Course 1. Hours as in 1.
Mj. Winter Quarter.
ASSOCIATE PROFESSOR SMITH.

3. **General Inorganic Chemistry.**— Continuation of Courses 1 and 2. Hours as in 1.
Mj. Spring Quarter.
ASSOCIATE PROFESSOR SMITH.

1, 2, 3 form a continuous course through three quarters.

The lectures and class-room work of 1, 2, and 3 may be taken by Graduate Students without the laboratory work or laboratory fee.

1A. **General Inorganic Chemistry.**—*Elementary Course.* DM. First Term, Summer Quarter.
Lectures 6 hrs. a week; 11:00.
Laboratory work 12 hrs. a week; 2:00–5:00.
ASSOCIATE PROFESSOR SMITH.

2A. **General Inorganic Chemistry.**— Continuation of Course 1A. Hours as in 1A.
DM. Second Term, Summer Quarter.
ASSOCIATE PROFESSOR SMITH.

The lectures and class-room work of 1A and 2A may be taken by Graduate Students without the laboratory work or laboratory fee.

Students offering entrance chemistry do more advanced laboratory work than those not offering it.

Courses 1 and 1A must be preceded by Preparatory (entrance) Physics or its equivalent, including some laboratory work.

The aim of the equivalent continuous Courses 1, 2, 3, and 1A and 2A will be to give a definite idea of the fundamental principles of chemistry, and not to overburden the student with a mass of unconnected facts. The lectures will be experimental to a considerable extent. The courses are designed to meet the wants not only of those who wish to go deeper into chemistry, but of all who wish to secure a liberal education.

1B. **General Inorganic Chemistry.**—*Special Course.*
DM. First Term, Summer Quarter.
Lectures, 6 hrs. a week; 11:00.
Laboratory work, 12 hrs. a week; 2:00–5:00.
ASSOCIATE PROFESSOR SMITH.
Mj. Autumn Quarter.
Class room 3 hrs. a week, 8:30.
Laboratory 6 hrs. a week. DR. MCCOY.

Prerequisite: *Entrance Chemistry and Physics, 1 unit each.*

2B. **General Inorganic Chemistry.**—*Special Course.* Continuation of Course 1B. Hours as in 1B (Summer).
DM. Second Term, Summer Quarter.
ASSOCIATE PROFESSOR SMITH.
Mj. Winter Quarter. Hours as in 1B (Autumn). DR. MCCOY.

1B and 2B, preceded by 1 unit entrance chemistry, are equivalent to the continuous 3Mj course. This is a special course designed to form a sequel to high-school chemistry. The lecture, laboratory, and recitation work are all distinct from that of Courses 1 and 2. Whenever the preparation justifies it, qualitative analysis (Course 6) may be substituted for 2B.

NOTE. — Two hours of laboratory are reckoned as equal to one hour of lecture work.

4. **Elementary Organic Chemistry.**
Class room 3 hrs. a week; 8:30.
½Mj. Spring Quarter.
DR. MCCOY.

Prerequisite: *General Chemistry.*

5. **Elementary Organic Chemistry.**
Laboratory course, 6 hrs. a week.
½Mj. Spring Quarter.
DR. MCCOY.

PRIMARILY FOR THE SENIOR COLLEGES.

NOTE.—Courses 6, 7, 8, 9, 10, 11, and 13 are given in the analytical laboratories. The laboratories are open from 8:00 A.M to 6:00 P.M. (Saturdays only to 1:00 P.M.) In the Autumn, Winter, and Spring Quarters, the *hours for instruction* in the laboratories are 2:00 to 5:30 P.M. Mondays to Thursdays, and 9:00 A.M. to 12:30 P.M. Fridays and Saturdays. Students are obliged to take at least two-thirds of the required laboratory work in the time allotted to instruction, and are required *to register for definite laboratory hours* on registering for a course in analytical chemistry.

6. **Qualitative Analysis.**—*Introductory Course.* Mj or DM. 8 or 16 hrs. a week laboratory. 2 hrs. a week class room. Lectures, 2:00.
Summer Quarter.
Associate Professor Stieglitz and Dr. McCoy.
Autumn and Spring Quarters.
Dr. Jones.

Prerequisite: *Courses 1, 2, 3,* or *1A, 2A,* or *1B and 2B.*

7. **Qualitative Analysis.**—Continuation of Course 6. Hours as in 6. Mj or DM. Summer Quarter.
Associate Professor Stieglitz and Dr. McCoy.
Autumn and Winter Quarters.
Dr. Jones.

Courses 6, 7, 10 form a continuous course, which may be begun in the Summer, Autumn, or Spring Quarters. The aim of Courses 6, 7, 10 will be to train the student to apply and amplify his knowledge of general and physical chemistry and to do intelligent analytical work based on a knowledge of the scientific principles of the subject.

8 **Quantitative Analysis.**—*Introductory Course.*—Chiefly laboratory work in gravimetric and volumetric analysis.
Mj or DM. 8 or 16 hrs. a week, laboratory. Lecture, 1 hour.
Summer, Autumn, and Winter Quarters.
Associate Professor Stieglitz.
Spring Quarter.
Dr. Jones.
(Mr. Derby or Mr. Shepherd, assisting in the Laboratory.)

Prerequisite: *Qualitative Analysis.*

9. **Quantitative Analysis.**—Continuation of Course 8. Mj or DM. 10 or 20 hrs. a week, laboratory.
Summer, Autumn, and Winter Quarters.
Associate Professor Stieglitz.
Spring Quarter.
Dr. Jones.

Courses 8, 9, 11 form a continuous course, which may be begun in any quarter.

Primarily for the Graduate School.

10. **Advanced Qualitative Analysis.**—Mj or DM. 10 or 20 hrs. a week, laboratory. Summer Quarter.
Associate Professor Stieglitz and Dr. McCoy.
Autumn, Winter, and Spring Quarters.
Dr. Jones.

Open to College students. Continuation of Courses 6 and 7.

11. **Advanced Quantitative Analysis.**—Mj or DM. 10 or 20 hrs. a week.
Summer, Autumn, and Winter Quarters.
Associate Professor Stieglitz.
Spring Quarter.
Dr. Jones.
(Mr. Derby or Mr. Shepherd, assisting in the Laboratory.)

Continuation of Courses 8 and 9. Open to students in the Senior Colleges.

12. **Elementary Spectrum Analysis** (Qualitative).—Emission (flame and electric spark) and absorption spectra of inorganic substances. Chiefly laboratory work. ½Mj. Winter Quarter.
Dr. Jones.

13. **Special Methods in Quantitative Analysis.**—Special analysis of water, ores, minerals, etc.; gas analysis; analysis by electrolytic methods. Chiefly laboratory work.
Summer, Autumn, and Winter Quarters.
Associate Professor Stieglitz.

Prerequisite: *Quantitative Analysis.*

Candidates for the degree of Ph.D. intending to pursue research work in Inorganic Chemistry will be required to take 2DM or 2Mj of this course; those intending to pursue research work in Organic Chemistry will be required to take one DM or Mj.

13B. **Assaying.**—Fire-assay of gold, silver, and lead ores. Mj. Winter Quarter.
Mr. Shepherd.

Prerequisite: *General Chemistry, Qualitative and Quantitative Analysis.* (Courses 9 and 10).

14. **Organic Chemistry.**—Lectures, 3 hrs. a week. Mj. Autumn Quarter; 12:00.
Professor Nef.

Prerequisite: *General Chemistry and Qualitative Analysis.*

15. **Organic Chemistry.**—Continuation of Course 14. Mj. Winter Quarter; 12:00.
Professor Nef.

16. **Organic Chemistry.**—Continuation of Course 15.
M. First Term, Spring Quarter; 12:00.
Professor Nef.

Courses 14, 15, 16 form a continuous course, covering the compounds of carbon, including the fatty and the aromatic series. The aim of the course will be to take up very thoroughly the simpler compounds, going with great detail into the chemical behavior, the characteristic reactions and relationships of the different classes of organic compounds, and considering with great care the synthetic methods by which they can be obtained. Richter's or Bernthsen's *Organic Chemistry* is used as a reference book, but recent literature will, in special cases, be considered in detail.

17. **General Organic Chemistry.**—Fatty and aromatic series.
Lectures, 5 hrs. a week.
Mj. (or M. First Term). Summer Quarter; 8:30.
Dr. Hessler.

Prerequisite: *General Chemistry and Qualitative Analysis.*

18. **Elementary Organic Preparations.**—Laboratory work; 10 hrs. a week. This course is arranged to accompany the lectures of Course 17. It may be taken without the lectures by students who have had organic chemistry.
½ Mj or Mj. Summer Quarter.
Dr. Hessler.
Prerequisite: *As in Course 17.*

19. **Toxicology.** M. Autumn Quarter.
Professor Haines and Assistant.

20. **Organic Preparations.** — Laboratory work, 10 or 20 hrs. a week. Mj or DM.
Autumn, Winter, and Spring Quarters.
Professor Nef.
Summer Quarter.
Dr. Hessler.

Prerequisite: *Qualitative and Quantitative Analysis*, and *Organic Chemistry* (it may be taken simultaneously in connection with lectures on Organic Chemistry).

21. **Organic Preparations.**—Continuation of Course 20. Mj or DM.
Autumn, Winter, and Spring Quarters.
Professor Nef.
Summer Quarter.
Dr. Hessler.

22. **Organic Preparations.** — Continuation of Course 21. Mj or DM.
Autumn, Winter, and Spring Quarters.
Professor Nef.
Summer Quarter.
Dr. Hessler.

Those intending to pursue research work in Inorganic Chemistry will be required to take 2Mj or 2DM of these courses, and those intending to pursue research work in Organic Chemistry will be required to take the 3Mj or 3DM. A reading knowledge of French and German is essential.

23. **Advanced General Chemistry.** — Causes of and conditions for chemical action. 2 hrs. a week.
½Mj. Autumn Quarter; 8:30.
Associate Professor Smith.

Prerequisite: *College Physics, General Chemistry, and Qualitative Analysis.*

24. **Advanced Inorganic Chemistry.**—Two lectures a week on selected topics. ½Mj.
Spring Quarter.
Dr. ———.

Prerequisite: *General Chemistry and Qualitative Analysis.*

25. **Inorganic Preparations.**—Laboratory work.
Mj or DM. 10 or 20 hours a week.
Summer, Autumn, and Winter Quarters.
Dr. McCoy.

Prerequisite: *Qualitative and Quantitative Analysis, and a reading knowledge of French and German.*

26. **Inorganic Preparations.**—Continuation of Course 25. Mj or DM.
Summer, Autumn, and Winter Quarters.
Dr. McCoy.

27. **Inorganic Preparations.**—Continuation of Course 26. Mj or DM.
Summer, Autumn, and Winter Quarters.
Dr. McCoy.

Those intending to pursue research work in Organic Chemistry will be required to take 2Mj. or 2DM of this course; those intending to engage in Inorganic Research will be required to take 3Mj or 3DM.

31. **Theoretical Chemistry.**—With special reference to physical methods. 2 hrs. a week.
Mj. (With 34 or 40) Summer Quarter; 8:30.
Mj. (With 34) Spring Quarter; 8:30.
Dr. McCoy.

Prerequisite: *College Physics and General Chemistry.*

33. **Research Work for Ph.D. Thesis.**—This course will include from 30 to 40 hrs. a week of laboratory work, under the special direction of some one of the instructors in the department. It is expected that a student will be occupied for a period of 4–8 quarters, 4–8 DMj.

33*a*. RESEARCH IN ORGANIC CHEMISTRY. — Autumn, Winter, and Spring Quarters.
PROFESSOR NEF.

33*b*. RESEARCH IN GENERAL CHEMISTRY.—Summer, Autumn, Winter, and Spring Quarters.
ASSOCIATE PROFESSOR SMITH.

33*c*. RESEARCH IN ORGANIC CHEMISTRY. — Summer, Autumn, and Winter Quarters.
ASSOCIATE PROFESSOR STIEGLITZ.

Before being admitted to Research, a candidate must satisfy the instructors of the department, by an oral test, or otherwise, that his previous training has been sufficient.

A candidate for the degree of Ph.D. must have taken Courses 1, 2, 3 (or 1*A*, 2*A*), (or 1*B*, 2*B*) 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 31, 32; the amount required of Courses 18, 19, 20 and 25, 26, 27; as well as at least eight ½Mj among the special Courses 12, 23, 24, 34, 35, 36, 37, 38, 39, 40, 41, 42, or their equivalent.

34. **Physico-Chemical Methods.** — Determination of specific gravity, molecular weights, etc.
Laboratory work, 5 hrs. a week.
Mj. (With 31 or 40) Summer Quarter.
Mj. (With 31) Spring Quarter.
Prerequisite: As in Course 31.
DR. McCOY.

35. **The Carbohydrates and the Terpenes** (and their derivatives).
Lectures, 2 hrs. a week.
½Mj. Autumn Quarter; 8:30.
ASSOCIATE PROFESSOR STIEGLITZ.
Prerequisite: *Organic Chemistry.*

36. **Organic Nitrogen Derivatives.**—Uric acid series; pyridine, quinone-imides, and phenazine compounds; a discussion of the alkaloids, ptomaines, and organic dye-stuffs.
Lectures, 2 hrs. a week.
½Mj. Winter Quarter; 8:30.
ASSOCIATE PROFESSOR STIEGLITZ.
Prerequisite: *Organic Chemistry.*

37. **Special Chapters of Organic Chemistry.**— Lectures, 4 hrs. a week.
M. Second Term, Spring Quarter; 12:00.
PROFESSOR NEF.
Prerequisite: *Organic Chemistry.*

38, 39. **The Aromatic Series.** — Lectures, 2 hrs. a week. Two ½Mj.
Autumn and Winter Quarters; 8:30.
ASSOCIATE PROFESSOR STIEGLITZ.
Prerequisite: *Organic Chemistry.*
[Not to be given in 1902–3.]

40. **The Teaching of Chemistry.**— A series of Conferences and Lectures on the Didactic of Chemistry.
Mj. (With 31 or 34) Summer Quarter, Wed; 2:00–4:00. ASSOCIATE PROFESSOR SMITH.

42. **History of Chemistry.** — 2 hrs. a week. Winter and Spring Quarters. Two ½Mj.
[Not to be given in 1902–3.]

43. **Journal Meetings.**
Autumn and Winter Quarters.
PROFESSOR NEF.

All candidates for the degree of Ph.D., and advanced students, will be present, and take part in turn in presenting and discussing recent investigations. Meetings will be held on alternate Fridays from 5:00 to 6:00. They may be attended by anyone interested, whether connected with the University or not; the subjects for the meetings will be announced at least one week beforehand.

THE KENT CHEMICAL LABORATORY.

OFFICERS OF GOVERNMENT.

JOHN ULRIC NEF, *Professor and Head of the Department of Chemistry.*
ALEXANDER SMITH, *Associate Professor of General Chemistry.*
JULIUS STIEGLITZ, *Associate Professor of Chemistry.*
JOHN C. HESSLER, *Instructor in Chemistry.*
HERBERT NEWBY McCOY, *Instructor in Chemistry.*
LAUDER W. JONES, *Instructor in Analytical Chemistry.*
WILLIS B. HOLMES, *Research Assistant in Chemistry.*
IRA M. DERBY, *Research Assistant in Chemistry.*
ROY HUTCHISON BROWNLEE, *Lecture Assistant in Chemistry*
THOMAS B. FREAS, *Laboratory Inspector.*
JOHN W. SHEPHERD, *Assistant in Quantitative Analysis.*

WALTER STANLEY HAINES, *Professor of Chemistry, Pharmacy, and Toxicology, Rush Medical College; Professorial Lecturer on Toxicology.*

THE BUILDING.

The Chemical Laboratory, provided by the generosity of Mr. Sidney A. Kent, was opened January 1, 1894.

The rooms are arranged as follows:

The *basement* contains a furnace room, with a set of gas furnaces, with air blast of the most modern construction, for crucible work, muffle work, tube heating, and other purposes; a constant temperature room, a room fitted with steam and other appliances for work on a large scale, a mechanical workshop, and storage rooms.

On the *first floor* are one small and two large lecture rooms, and a large lecture hall seating three hundred persons, fitted for use as a chemical lecture room, if desired. This floor also contains a chemical museum, a large private laboratory, a room with northern exposure, especially fitted for use as a gas analysis laboratory, and also apparatus and preparation rooms connected with the lecture rooms.

On the *second floor* are two large laboratories intended for research and quantitative analysis, three private laboratories for the professors, balance, combustion, air furnace, and storerooms, a balcony for out-of-door work, and the chemical library, which contains full sets of the most important journals, as well as the most important text-books and other works, relating to chemistry.

On the *third floor* are three large laboratories for general and analytical chemistry, a storeroom, a preparation room, a room especially fitted for optical and photographic work, a balance room, and two private laboratories. The most modern system of ventilation has been adopted, air of constant temperature being forced in by fans from below, and withdrawn by a fan above. The building will be lighted throughout by electric lights, and the laboratories will be provided with electricity adapted to every kind of electro-chemical work.

The fullest opportunity will be given for doing research work. All possible aid will be afforded those who desire to avail themselves of the facilities of the laboratory.

The University will be glad to answer inquiries from institutions looking for well-equipped teachers in Physics and Chemistry.

Letters of inquiry and requests for documents should be addressed to

THE UNIVERSITY OF CHICAGO,
CHICAGO, ILL.

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1902-03

The University of Chicago

FOUNDED BY JOHN D. ROCKEFELLER

PROGRAMME OF THE DEPARTMENTS OF

MATHEMATICS

AND

ASTRONOMY AND ASTROPHYSICS

1902-1903

CHICAGO
The University of Chicago Press
1902

CONSPECTUS OF COURSES, 1902–1903

XVII. MATHEMATICS

SUMMER	AUTUMN	WINTER	SPRING
1 Trigonometry (Young) 2 College Algebra (Dickson) 3 Analytics (Dickson)	0*a* Solid Geometry (———) 0*b* Solid Geometry. (———) 1*a* Trigonometry (Young, Dickson, ——) 1*b* Trigonometry (Young, Dickson, ——)	0 Solid Geometry (———) 1*a* Trigonometry (———, ———) 1*b* Trigonometry (———) 2*a* College Algebra (Young, Dickson, ———) 2*b* College Algebra (Young, Dickson, ———)	1 Trigonometry (———) 2*a* College Algebra (———, ———) 2*b* College Algebra (———) 2A Surveying and Navigation (Dickson) 3 Analytics (Dickson, ———) 4. Calculus (Young)
12 Differential Calculus (Moore) 14 Integral Calculus DM 1T (Slaught)	11 Calculus I (Moore)	13 Calculus II (Moore)	15 Calculus III (Moore)
20 Theory of Equations (Young) 22 Analytic Mechanics (Lunn) 24 Advanced Integral Calculus (Lunn) 26 Differential Equations M 2T (Veblen) 30 Conferences on the Pedagogy of Mathematics (Young) 35A, C Mathematical Reading (Moore, Maschke) 47 Higher Plane Curves (Maschke) 53A Foundations of Geometry (Moore) 55 Elliptic Functions (Maschke) 60 Substitution Groups [Dickson)	17 Theory of Equations I (Bolza) 23 Advanced Integral Calculus I (Maschke) [Astronomy 5.] Analytic Mechanics I (Moulton) 35A, B, C Mathematical Reading (Moore, Bolza, Maschke) 45 Projective Geometry (Moore) 46 Modern Analytic Geometry (Maschke) 52 Theory of Functions I (Bolza) 59 Finite Groups (Dickson)	19 Theory of Equations II (Bolza) 25 Advanced Integral Calculus II (Maschke) [Astronomy 6.] Analytic Mechanics II (Moulton) 35A, B, C Mathematical Reading (Moore, Bolza, Maschke) 47 Higher Plane Curves (Maschke) 52A Theory of Functions II (Bolza) 49 Continuous Groups (Dickson) 62 General Arithmetic (Moore)	21 Solid Analytics (Young) 27 Advanced Integral Calculus III (Maschke) 35A, C Mathematical Reading (Moore, Maschke) 46 Theoretical Mechanics (———) 54 Linear Differential Equations (Maschke) 70 Seminar A (Moore)

XVII. THE DEPARTMENT OF MATHEMATICS.

OFFICERS OF INSTRUCTION.

ELIAKIM HASTINGS MOORE, PH.D., *Professor and Head of the Department of Mathematics.*
OSKAR BOLZA, PH.D., *Professor of Mathematics.*
HEINRICH MASCHKE, PH.D., *Associate Professor of Mathematics.*
WILLIAM HOOVER, PH.D., *Non-Resident University Extension Assistant Professor of Mathematics.*
HERBERT ELLSWORTH SLAUGHT, PH.D., *Assistant Professor of Collegiate Mathematics; Departmental Examiner.**
JACOB WILLIAM ALBERT YOUNG, PH.D., *Assistant Professor of the Pedagogy of Mathematics.*
LEONARD EUGENE DICKSON, PH.D., *Assistant Professor of Mathematics.*
JAMES HARRINGTON BOYD, SC.D., *Instructor in Mathematics.**

ARTHUR CONSTANT LUNN, A.M., *Instructor in Mathematics and Astronomy, Wesleyan University* (Summer Quarter, 1902).

FELLOWS.

1902-1903.

WILLIAM HENRY BUSSEY, A.B.
WALTER WILSON HART, A.B.
ARCHIBALD HENDERSON, PH.D.
HERBERT EDWIN JORDAN, A.B.
KARL DALE SWARTZEL, S.M.
OSWALD VEBLEN, A.B.

THE SCHEME OF THE COURSES OF INSTRUCTION.

COLLEGIATE ENTRANCE REQUIREMENTS.

1. *Algebra*—through radicals, exponents, imaginaries, and theory of quadratic equations. (Special attention should be given to the solution of equations and to miscellaneous problems involving equations.)
2. *Plane Geometry.* } (The demonstration of original propositions and the solution of original problems will
3. *Solid Geometry.* } be required.)

Algebra and *Plane Geometry* are prescribed entrance requirements; *Solid Geometry* is an elective entrance requirement.

COURSES IN ELEMENTARY MATHEMATICS.

Course 0, *Solid Geometry* (Autumn Quarter) is to be taken by those students entering without solid geometry.

The regular Junior College courses are: Course 1, *Trigonometry;* Course 2, *College Algebra,* including the elementary theory of finite and infinite algebraic and trigonometric series; Course 2A, *Surveying and Navigation;* Course 3, *Analytic Geometry;* Course 4, *Calculus* (shorter course); and Courses 11, 13, 15, *Calculus* (longer course). The arrangement of sections for the year 1902–3 is given below. In their first year of residence Junior College students of the College of Science are required to take Courses 1, 2, 3; other Junior College students are required to take Courses 1, 2. Course 2A may however be substituted for Course 2, and Course 4 for Course 3. The required work in Mathematics should be taken as soon after entrance as possible.

Students who expect to specialize in Mathematics, Astronomy, Physics, or Chemistry should take Courses 1, 2, 3, 11, 13, 15. Students who expect to specialize in other sciences, or who desire to have at least a glimpse beyond the elements of Mathematics, should elect one or both of Courses 3 and 4.

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* On leave of absence.

INITIAL COURSES IN THE HIGHER MATHEMATICS.

The following courses introductory to the higher Mathematics are intended for students making Mathematics their principal subject, and partly also for those making Mathematics their secondary subject, in particular for students of Astronomy and Physics:

(*A*) †*Differential and integral calculus* (*3Mj*).

(*B*) † *Theory of equations, including determinants* (*2Mj*); *solid analytics.*

(*C*) † *Advanced integral calculus, including definite integrals, Fourier series, elements of elliptic integrals and functions, differential equations* (*3Mj*).

(*D*) † *Analytic mechanics* (*2Mj.*); *theoretical mechanics.*

(*E*) *Projective geometry; modern analytic geometry; differential geometry* (*2Mj*).

(*F*) † *Elements of the theory of functions* (*2Mj*); *calculus of variations; theory of the potential, elliptic functions; linear differential equations.*

(*G*) *Theory of numbers; theory of invariants; selected chapters of algebra; theory of substitutions with applications to algebraic equations; quaternions.*

The groups (*A*)–(*G*) indicate the permanent constituents of seven sequences of courses running through the usual academic year from October to June. These sequences vary slightly from year to year, the courses marked with a dagger (†) being given annually, and the other courses being given usually once in two years. Special emphasis will be laid upon the application of calculus to the solution of analytical, geometrical, and mechanical problems.

The undergraduate student who wishes to specialize in Mathematics should take (*A*) as Junior College Elective, (*B*) in his first Senior College year, and (*C*) and (*D*) in his second Senior College year.

Candidates for the Master's degree with Mathematics as principal subject are expected to offer for examination the subjects covered by the courses of groups (*A*)–(*D*), and three Majors selected from (*E*)–(*G*), or the equivalents of these subjects, and to present a satisfactory thesis on an assigned topic closely related to one of these subjects.

Candidates for the Doctor's degree with Mathematics as secondary subject are expected to offer for examination the subjects covered by the courses of groups (*A*)–(*D*), and one Major selected from (*E*)–(*G*), or the equivalents of these subjects.

SPECIAL COURSES IN THE HIGHER MATHEMATICS.

The science of Mathematics embraces the four highly related but independent sciences: Algebra and Arithmetic, Analysis, Geometry, and Mechanics.

The department offers the following courses in the higher Mathematics:

Algebra and Arithmetic.—Initial courses in groups (*B*) and (*G*), and special courses as follows: *Linear substitution groups; congruence groups; abstract groups; algebraic numbers; general arithmetic; and research Seminars.*

Analysis.—Initial courses in groups (*A*), (*C*), and (*F*), and special courses as follows: *Theory of functions of real and of complex variables; Lie's theory of differential equations; continuous groups; elliptic functions; hyperelliptic functions; abelian functions; elliptic modular functions; and research Seminars.*

Geometry.—Initial courses in groups (*B*) and (*E*), and special courses as follows: *Differential geometry; higher plane curves; algebraic surfaces; Lie's theory of differential equations; continuous groups; linear substitution groups; and research Seminars.*

Mechanics.—Initial courses in groups (*D*) and (*F*). Special courses in Mechanics, and especially in Celestial Mechanics, are offered by the Department of Astronomy, while special courses in Theoretical Physics are offered by the Department of Physics.

The initial and special courses in the higher Mathematics are intended to give the graduate student a comprehensive view of modern Mathematics, to develop him to scientific maturity, and to enable him to follow, without further guidance, the scientific movement of the day, and, if possible, to take an active part in it by creative research. The special courses and the research Seminars vary from year to year.

Candidates for the Doctor's degree with Mathematics as principal subject are expected to present a dissertation, in finished form, embodying valuable results of mathematical inquiry, and to offer for examination the subjects covered by the initial courses of groups (*A*)–(*G*), and by a considerable body of special courses, in each case presumably most closely related to the subject of the candidate's dissertation.

GENERAL STATEMENT TO STUDENTS OF MATHEMATICS.

Students of Mathematics should understand that the proper arrangement of their course of study in Mathematics is a matter of extreme importance. The best arrangement for a particular student is apt to depend on his previous mathematical career, and can be determined often only by conference between the student and a member of the staff of the department. The members of the staff are at all times ready to arrange for such conferences.

THE SUMMER QUARTER.

The courses of the Summer Quarter are designed to meet the needs of those college men and others wishing to study advanced Mathematics, who are able to spend only the summer in residence. The courses of a series of four summer quarters will be arranged so as to give a wide view of modern Mathematics. Every summer there is given a course on the Pedagogy of Mathematics.

The attention of any student wishing the guidance of the department in his continuation of the work done in the summer is called to the correspondence courses of the department, which are given under the auspices of the University Extension Division of the University.

FELLOWSHIPS IN MATHEMATICS.

To students in Mathematics are usually assigned three or four Fellowships. These Fellowships are assigned to those students excelling in their mathematical acquisitions and scholarly abilities who exhibit strongest evidences of marked creative ability in Mathematics. It is a distinct advantage to candidates to have been at least one year in residence at the University. Candidates should file with the President of the University (on application blanks to be secured from the President's Secretary) records of their previous work and distinctions, degrees, and past courses of study, with copies of their written or printed work in Mathematics. Applications should be filed before March 1 of each year. The appointments are made at the Spring Convocation of the University.

Fellows agree not to give private tuition, and may be called upon for assistance in any departmental teaching or other work; in no case, however, will a Fellow be expected or permitted to devote more than one sixth of his time to such service.

SCHOLARSHIPS IN MATHEMATICS.

Senior College Scholarship.—This Scholarship is awarded annually at the Summer Convocation to that student admitted to the Senior College during the preceding year who did the best Junior College work in Mathematics. In judging of the work of each candidate for this Scholarship the department considers (*a*) the general quality of his Junior College work; (*b*) the quantity and the quality of his Junior College work in Mathematics; (*c*) the results of the Senior College Scholarship Examination on the subjects: *Trigonometry, College Algebra, and Analytical Chemistry.*

Graduate Scholarship.—This Scholarship is awarded annually at the Summer Convocation to that student admitted to the Ogden Graduate School during the preceding year who has been named by the department as the Senior College honor student in Mathematics. In judging of the work of each candidate for this Scholarship the department considers (*a*) the quantity and the quality of his Senior College work in Mathematics; (*b*) the results of the Graduate Scholarship Examination on the subjects: *Differential and Integral Calculus, Theory of Equations, Solid Analytics, and Advanced Integral Calculus;* (*c*) his promise of success as a graduate student of Mathematics.

Scholarship Examinations.—The Senior College Scholarship Examination and the Graduate Scholarship Examination are held every Spring Quarter at times and places duly announced in the *Weekly Calendar* or the *University Record.* Prospective candidates should confer with the Departmental Examiner. Files of papers set at previous Scholarship Examinations are accessible in the Departmental Library.

MATERIAL FACILITIES OF THE DEPARTMENT.

Library.—The Mathematical Library occupies Room 37 of the Ryerson Physical Laboratory, adjacent to the lecture-rooms of the department, and is open for the use of graduate students from 8:30 A.M. to 6:00 P.M. The library contains the more important mathematical periodicals, collected works, treatises, and text-books.

Models.— A collection of Brill's models: Plaster and thread models of quadric surfaces, plaster models of cubic and Kummer's quartic surfaces, models of cyclides and surfaces of constant positive and negative curvature, and thread models of three-dimensional projections of four-dimensional regular bodies.

COURSES OF INSTRUCTION.

Summer Quarter, 1902—Spring Quarter, 1903.

M=Minor course=a single course for six weeks. DM=Double Minor course=a double course (two hours daily) for six weeks. Mj=Major course=a single course for twelve weeks. DMj=Double Major course=a double course for twelve weeks.

I. Junior College Courses.

[Note.—Any student permitted to matriculate with entrance conditions in Mathematics is expected to remove these conditions at the next regular entrance examination, and, until this has been done, he may not begin his required college mathematics.]

0. **Solid Geometry.**

Mj. Autumn Quarter.
Sec. 0*a* Mr. ———.
Sec. 0*b* Mr. ———.
Mj. Winter Quarter.
Mr. ———.

Required of all students who were not credited with Solid Geometry on admission.

1. **Trigonometry.**—Plane trigonometry, with an introduction to spherical trigonometry.

Mj. Summer Quarter.
Assistant Professor Young.
Mj. Autumn Quarter.
In two divisions of graded sections.
Div. 1*a*
Assistant Professor Young.
Assistant Professor Dickson.
Mr. ———.
Div. 1*b*
Assistant Professor Young.
Assistant Professor Dickson.
Mr. ———.
Mj. Winter Quarter.
In graded sections.
Div. 1*a*
Mr. ———.
Mr. ———.
Div. 1*b* Mr. ———.
Mj. Winter Quarter.
Mr. ———.

Required of all students.

2. **College Algebra.**—The elementary theory of finite and infinite algebraic and trigonometric series.

Mj. Summer Quarter.
Assistant Professor Dickson.
Mj. Winter Quarter.
In two divisions of graded sections.
Div. 2*a*
Assistant Professor Young.
Assistant Professor Dickson.
Mr. ———.
Div. 2*b*
Assistant Professor Young.
Assistant Professor Dickson.
Mr. ———.
Mj. Spring Quarter.
In graded sections.
Div. 2*a*
Mr. ———.
Mr. ———.
Div. 2*b* Mr. ———.

Required of all students. (See Course 2A.)

2A. **Surveying and Navigation.**—This course includes practical work with surveying instruments.

Mj. Spring Quarter.
Assistant Professor Dickson.

Prerequisite: *Course 1.*

This course may be substituted for Course 2 as a required course. Course 2 is, however, a prerequisite for Course 3.

3. **Analytic Geometry.**—Elements of plane analytics, including the geometry of the conic sections, with an introduction to solid analytics.

Mj. Summer Quarter.
Assistant Professor Dickson.
Mj. Spring Quarter.
In graded sections.
Div. 3*a*
Assistant Professor Dickson.
Mr. ———.

Prerequisite: *Courses 1 and 2.*

Required of all students in the College of Science. (See Course 4.)

4. **Calculus** (shorter course).—The fundamental principles and the general methods will be carefully studied, and illustrated by simple applications arising in mathematics and the physical sciences.

Mj. Spring Quarter.
Assistant Professor Young.

Prerequisite: *Courses 1 and 2 (Trigonometry and College Algebra). Course 3 (Analytic Geometry) is desirable, but not indispensable.*

This course is intended for those who do not wish to take the longer course in Calculus (three quarters), but who, nevertheless, desire to round out their previous mathematical work with some knowledge of a subject of such great importance, both in pure mathematics and the natural sciences, as the Calculus. Certain students expecting to take the longer course in Calculus may advisably take this course as an introductory course.

Students of the College of Science may take Course 4 instead of Course 3 as a required course.

Junior College Elective. — The Courses 11, 13, 15; *Calculus* I, II, III, should be taken as Junior College Elective in their second year of residence by those students intending to make a special study of Mathematics, the required Courses 1, 2, 3 having been taken in their first year of residence.

12. **Differential Calculus.** — Based on Lamb's *Infinitesimal Calculus.* Laboratory method.
Mj. Summer Quarter.
Professor Moore.

Prerequisite: *Courses 1, 2, 3 (Courses 3 and 12 may, however, be taken simultaneously).*

14. **Integral Calculus.**—A first view.
DM. First Term, Summer Quarter.
Assistant Professor Slaught.

Prerequisite: *Differential Calculus.*

11, 13, 15. **Calculus I, II, III.**—The fundamental principles and processes of the differential and integral calculus, with much attention to the solving of problems illustrating all phases of the theory and certain important applications to geometry and mechanics and physics. Laboratory method.

Three consecutive Majors. Autumn, Winter. and Spring Quarters; 2:00–4:00.
Professor Moore.

Prerequisite: *Courses 1, 2, 3.*

Note.—Courses 11 and 17 may be taken simultaneously.

II. Senior College Courses.

17, 19. **Theory of Equations, I, II.**—Rational functions. Binary quantics. Symmetric functions. Invariants. Separation of and numerical approximation to the roots of an equation. Determinants and theory of systems of linear equations. Geometric theory of the real and of the complex variable. Limits. Infinite series and products. Hypergeometric series. Continued fractions. Roots of unity.
2Mj. Autumn and Winter Quarters.
Professor Bolza.

Prerequisite: *Plane Analytics and Differential Calculus.*

Note.—Courses 11 and 17 may be taken simultaneously.

16. **Solid Analytics and Determinants.**
Mj. Summer Quarter.

Prerequisite: *Plane Analytics and Calculus.*

Note.—Courses 12 and 16 may be taken simultaneously.

[Not to be given in 1902.]

18. **Determinants.**—The elementary theory of determinants, together with certain important applications. M. First Term, Summer Quarter.

Prerequisite: *College Algebra.*

[Not to be given in 1902.]

20. **Theory of Equations.**—Based on Burnside and Panton's *Theory of Equations.*
Mj. Summer Quarter.
Assistant Professor Young.

Prerequisite: *Analytic Geometry and Differential Calculus.*

21. **Solid Analytics.** —Elements of analytic geometry of three dimensions. Quadric surfaces. Theory of curvature of twisted curves and surfaces.
Mj. Spring Quarter.
Assistant Professor Young.

Prerequisite: *Plane Analytics and Differential Calculus.*

[Astronomy 5, 6.] **Analytic Mechanics I, II.** — Bowser's *Analytic Mechanics*, supplemented by lectures.
2Mj. Autumn and Winter Quarters.
Dr. Moulton.

Prerequisite: *Differential and Integral Calculus.*

22. **Analytic Mechanics.**—An introductory course.
Mj. Summer Quarter.
Mr. Lunn.

Prerequisite: *Differential and Integral Calculus.*

23, 25, 27. **Advanced Integral Calculus I, II, III.**—Including ordinary differential equations, definite integrals, Fourier's series, and the elements of elliptic integrals and functions, and of partial differential equations, with especial attention to applications to geometry, mechanics, and physics.

3Mj. Autumn, Winter, and Spring Quarters
Associate Professor Maschke.

Prerequisite: *Calculus and Advanced Algebra.*

24. **Advanced Integral Calculus.**— Including definite integrals and their geometric applications.

Mj. Summer Quarter.

Mr. Lunn.

Prerequisite: *Calculus.*

26. **Differential Equations.** — An elementary course in ordinary differential equations, with especial attention to certain important applications.

M. Second Term, Summer Quarter.

Mr. Veblen.

Prerequisite : *Differential and Integral Calculus.*

III. Graduate Courses.

30. **Conferences on the Pedagogy of Mathematics.** Selected topics from the teaching of preparatory and collegiate mathematics will be considered.

Mj. Summer Quarter.

Assistant Professor Young.

35 A, B, C. **Mathematical Reading and Research.** When in the judgment of the department it is advisable that students undertake definite mathematical reading and research not closely connected with any current lecture course or seminar, this work will be directed by one or other of

Professors Moore, Bolza, Maschke.

36. **Theoretical Mechanics.** — Advanced course in analytic mechanics, with reference-use of Appell's *Mécanique Rationelle.*

Mj. Spring Quarter.

Mr. ————.

Prerequisite: *Analytical Mechanics I, II, and Differential Equations.*

38. **Selected Chapters of Algebra.**

Associate Professor Maschke.

Prerequisite : *Courses 17, 19, 21, 23, 25.*

[Not to be given in 1902–3.]

40. **Calculus of Variations.**—An advanced course on the theory of maxima and minima of definite integrals, chiefly based upon Weierstrass' lectures, with numerous applications to problems of geometry and mechanics.

Professor Bolza.

Prerequisite : *Advanced Integral Calculus*, and a facility in abstract mathematical reasoning.

[Not to be given in 1902–3.]

41. **Quaternions.**— Introduction to the general theory, with applications to geometry and mechanics.

Mj. Summer Quarter.

Prerequisite : *Plane and Solid Analytics, and Calculus.*

[Not to be given in 1902.]

44. **Twisted Curves and Surfaces.**—Differential geometry. A course introductory to Course 76; Seminar C.

Assistant Professor Maschke.

Prerequisite : *Courses 21, 23, 25, and 27.*

[Not to be given in 1902–3.]

45. **Projective Geometry.** — An introductory course based on Holgate's translation of the first volume of Reye's *Geometrie der Loge.*

Mj. Autumn Quarter.

Professor Moore.

46. **Modern Analytic Geometry.** — Homogeneous (trilinear) coördinates; projective properties of conics. Mj. Autumn Quarter.

Associate Professor Maschke.

Prerequisite : *Courses 11, 13, 15, 17, 19, 21, and 45.*

47. **Higher Plane Curves.**—General properties of algebraic curves. Special study of the curves of the third and fourth order.

Mj. Summer Quarter.

Associate Professor Maschke.

Mj. Winter Quarter.

Associate Professor Maschke.

Prerequisite : *Course 46.*

48. **Algebraic Surfaces.**—General theory. Most important properties of algebraic surfaces of the third order and of certain other general classes of surfaces. Line geometry.

Mj. Spring Quarter.

Associate Professor Maschke.

Prerequisite : *Course 47.*

[Not to be given in 1903.]

49. **Continuous Groups.** — Introduction to the Lie theory, with extensive applications to the integration of ordinary and partial differential equations and to geometry.

Mj. Winter Quarter.

Assistant Professor Dickson.

Prerequisite : *Course 21, 23, 25, 27.*

50. **Theory of Invariants.** — Linear substitutions, theory of quantics ("modern higher algebra"), with applications to the theory of equations and to geometry.
Associate Professor Maschke.
Prerequisite: *Courses 17, 19, 23, 25.*
[Not to be given in 1902–3.]

51. **Theory of Functions of a Complex Variable.**—The elements of the theories of Cauchy and of Weierstrass. Mj. Summer Quarter.
Prerequisite: *Courses 19, 21, and 23.*
[Not to be given in 1902.]

52, 52A. **Theory of Functions, I, II.**—I: Complex numbers. The linear fractional function. Conform representation. The limit notion. Critical review of the principles of the infinitesimal Calculus. Infinite series and products. Definite integrals. — II: Cauchy's theory of functions of a complex variable. Power series. Elements of Weierstrass' theory of analytic functions. Riemann's surface.
2Mj. Autumn and Winter Quarters.
Professor Bolza.
Prerequisite: *Courses 17, 19, 21, 23, 25, 27.*

52B. **Theory of the Potential.**—With applications to problems of mechanics and physics. Spherical and cylindrical harmonics, with application to the theory of the potential.
Mj. Spring Quarter.
Associate Professor Maschke.
Prerequisite: *Courses 52, 52A.*
[Not to be given in 1903.]

53. **Theory of Functions of Real Variables.** — Critical exhibition of the fundamental properties of the real variable and of certain classes of functions of real variables. Professor Moore.
Prerequisite: *Courses 19, 21, and 23,* and a facility in abstract mathematical reasoning.
[Not to be given in 1902–3.]

53A. **Foundations of Geometry.**—Geometry as a purely abstract deductive science.
Mj. Summer Quarter.
Professor Moore.
Prerequisite: A facility in abstract mathematical reasoning.

54. **Linear Differential Equations.**—The general theory with particular reference to differential equations of second order. Special study of the hypergeometric function.
Mj. Spring Quarter.
Associate Professor Maschke.
Prerequisite: *Course 52A.*

55. **Elliptic Functions.**
Mj. Summer Quarter.
Associate Professor Maschke.
Prerequisite: *Course 51.*

55A. **Applications of Elliptic Functions.** — A continuation of Course 55.
Professor Bolza.
[Not to be given in 1902–3.]

56. **Hyperelliptic Functions.**—According to Riemann and Klein. Professor Bolza.
Prerequisite: *Course 53.*
[Not to be given in 1902–3.]

57. **Abelian Functions.**
Professor Bolza.
Prerequisite: *Course 52A.*
[Not to be given in 1902–3.]

58. **Linear Substitution Groups.**—The fundamental principles of the theory of groups. Deduction and discussion of binary, ternary, and certain quaternary substitution groups of finite order. Associate Professor Maschke.
Prerequisite: *Courses 47 and 52A.*
[Not to be given in 1902–3.]

59. **Finite Groups.**—Introduction to the theory of substitution groups with applications to the theory of algebraic equations. Seminar reports on selected topics concerning abstract groups, linear groups in a field, collineation groups.
Prerequisite: A facility in abstract mathematical reasoning.
Mj. Autumn Quarter.
Assistant Professor Dickson.

59A. **Elliptic Modular Functions.** — A sketch of the general theory of the modular equation, with especial attention to certain illustrative algebraic and transcendental resolvents.
Professor Moore.
Prerequisite: *Courses 52A, 55, and 59.*
[Not to be given in 1902–3.]

60. **Theory of Substitutions,** with applications to the theory of algebraic equations.

Mj. Summer Quarter.
ASSISTANT PROFESSOR DICKSON.

61. **Theory of Numbers.**—The elements of the theory, with an introduction to the theory of congruence groups.

Prerequisite: No specific subjects, but a facility in abstract mathematical reasoning.

[Not to be given in 1902–3.]

62. **General Arithmetic.** — The theory of integral functions of indeterminates with integral coefficients, with application to the theory of algebraic numbers and functions. To be followed by Course 70. Mj. Winter Quarter.
PROFESSOR MOORE.

Prerequisite: The Elements of the Theory of the Numbers.

[Not to be given in 1902.]

64. **Algebraic Numbers.**—The classical theories and current researches. Hilbert's report "Die algebraischen Zahlkörper" (Berlin, Reimer, 1897) should be in the hands of the student.
PROFESSOR MOORE.

[Not to be given in 1902–3.]

THE SEMINARS.

Advanced students engaged in or prepared to undertake research work may, on approval of its Director, enter one of the Seminars. The individual members of a Seminar from time to time report to the Seminar on their investigations or on assigned topics. Each Seminar considers in particular certain topics; these topics vary somewhat from year to year. The research work of candidates for the doctorate receives particular attention and direction.

70. **Seminar A.**—Selected topics in general Arithmetic. In continuation of Course 62.

Mj. Spring Quarter.
PROFESSOR MOORE.

73. **Seminar B.**—Selected topics in the theory of Abelian functions. PROFESSOR BOLZA.

[Not to be given in 1902–3.]

76. **Seminar C.**—Selected topics in differential geometry. ASSOCIATE PROFESSOR MASCHKE.

[Not to be given in 1902–03.]

XVIII. THE DEPARTMENT OF ASTRONOMY AND ASTROPHYSICS.

OFFICERS OF INSTRUCTION.

GEORGE ELLERY HALE, Sc.D., *Professor of Astrophysics, and Director of the Yerkes Observatory.*
SHERBURNE WESLEY BURNHAM, A.M., *Professor of Practical Astronomy, and Astronomer in the Yerkes Observatory.*
EDWARD EMERSON BARNARD, A.M., Sc.D., *Professor of Practical Astronomy, and Astronomer in the Yerkes Observatory.*
EDWIN BRANT FROST, A.M., *Professor of Astrophysics, and Astrophysicist in the Yerkes Observatory.*
KURT LAVES, Ph.D., *Assistant Professor of Astronomy.*
FOREST RAY MOULTON, A.B., Ph.D., *Instructor in Astronomy.*
GEORGE WILLIS RITCHEY, *Instructor in Practical Astronomy, and Superintendent of Instrument Construction at the Yerkes Observatory.*
FERDINAND ELLERMAN, *Instructor in Astrophysics at the Yerkes Observatory.*
STORRS BARROWS BARRETT, A.B., *Secretary and Librarian of the Yerkes Observatory.*
WALTER SIDNEY ADAMS, A.M., *Assistant at the Yerkes Observatory.*
JOHN ADELBERT PARKHURST, S.M., *Assistant at the Yerkes Observatory.*
NORTON ADAMS KENT, Ph.D., *Assistant at the Yerkes Observatory.*

FELLOW.

1902-1903.

RAY YALDING FERNER, A.B.

INTRODUCTORY.

The work of the Department of Astronomy and Astrophysics naturally divides itself into two parts:

1. Work at the University, comprising: (*a*) elementary instruction in general Astronomy, both theoretical and practical; (*b*) preliminary training in the principles and methods of work underlying the science of Astrophysics, given in part in the undergraduate and graduate courses offered by the Department of Physics; (*c*) graduate and research work in Celestial Mechanics.
2. Graduate and research work in the Yerkes Observatory at Lake Geneva.

UNIVERSITY WORK.

In the work at the University, given by Assistant Professor Laves and Dr. Moulton, special emphasis will be laid on the development of the mathematical methods and principles which lie at the basis of the physical sciences. In addition to the annual courses in Descriptive Astronomy, Introduction to Celestial Mechanics, Spherical and Practical Astronomy, Orbits and Ephemerides, and Analytical Mechanics, courses in the various branches of Celestial Mechanics will be given within periods not exceeding three years. The most fundamental subjects will be arranged in a cyclic manner so as to recur at regular intervals, while other more special topics will vary from time to time.

The general object of the instruction will be: (1) to furnish the student an adequate mathematical basis for successful work in Celestial Mechanics; (2) to give such experience and preliminary training in the work of observation and reduction as will enable the student to use intelligently and skillfully any of the astronomical or astrophysical instruments of a modern observatory; (3) to direct the attention of advanced students to the fundamental problems of modern Astronomy and Astrophysics, and to encourage work of research likely to yield contributions to science.

OBSERVATORY WORK.

In the work at the Observatory attention will be devoted both to the investigations of Practical Astronomy and to those of Astrophysics. The rapid development of the latter science within the last few years has been fully recognized and amply provided for in the design of the Observatory and in its instrumental equipment. The special laboratory facilities will render possible many astrophysical investigations which are necessarily neglected in other institutions. The Observatory will be open to those students only who have completed the necessary preliminary work at the University or its equivalent at other institutions.

GRADUATE AND RESEARCH WORK.

Undergraduate Students, in the S.B. course, who desire to specialize along the line of Astronomy, are recommended to take *six Majors* in Mathematics, viz.: Differential and Integral Calculus 3; Solid Analytic Geometry 1; Advanced Integral Calculus 2; and *three Majors* in Astronomy, viz.: Descriptive Astronomy, Introduction to Celestial Mechanics, and Spherical and Practical Astronomy.

Graduate Students working for the Master's degree are recommended to choose *three Majors* in the Department of Mathematics, viz.: Differential Equations 1; Theory of Equations 2; or in the Department of Physics, viz.: Advanced General Physics 3; and *six Majors* in the Department of Astronomy.

Candidates for the degree of Doctor of Philosophy are expected to make their secondary subject either Mathematics or Physics. Students intending to specialize in the lines of Astrophysics will be required to take the work in Advanced General Physics, Advanced Laboratory Practice, Laboratory Methods, and Spectrum Analysis.

SCHOLARSHIPS, FELLOWSHIPS, DOCENTSHIPS.

Graduate Scholarships, Fellowships, and Docentships, will be assigned in accordance with the general regulations of the University. Details regarding the appointment of Volunteer Research Assistants and Special Investigators at the Yerkes Observatory may be found on page 16 of this PROGRAMME.

DEPARTMENTAL CLUB.

The Club meets fortnightly on Fridays at 4 : 00 P.M. in the Ryerson Physical Laboratory, Room 35, for the review of memoirs and books, and for the presentation of results of research. The Club is conducted by the members of the Faculties of Mathematics and Mathematical Astronomy. Graduate students of Mathematical Astronomy are expected to attend regularly and, so far as possible, to participate actively in the meetings of the Club.

EQUIPMENT.

The Department of Astronomy at the University occupies at present rooms on the third floor of the Ryerson Physical Laboratory. For the purpose of instruction in Practical Astronomy a Students' Observatory, consisting temporarily of two small buildings, has been provided on the northeastern quadrangle. It is equipped with a modern Warner and Swasey equatorial telescope of 6½-inches aperture, provided with a filar micrometer with position circle, a Bamberg universal instrument, a chronometer, and various smaller accessories. The laboratory courses offered by the Department of Physics afford excellent preliminary training for the work in Astrophysics.

A description of the Yerkes Observatory at Lake Geneva and its equipment will be found on pages 15, 16 of this PROGRAMME.

LIBRARY FACILITIES.

The Astronomical Library is open to graduate students under the same conditions as the Mathematical Library, with which it is associated. The Astronomical Library includes many of the fundamental works on Astronomy, several sets of annals, and a number of journals.

PUBLICATIONS.

The publications of the Department are enumerated in the description of the Observatory.

COURSES OF INSTRUCTION,

Summer Quarter, 1902—Spring Quarter, 1903.

M=Minor course=a single course for six weeks. DM=Double Minor course=a double course (two hours daily) for six weeks. Mj=Major course=a single course for twelve weeks. DMj=Double Major course=a double course for twelve weeks.

At the University.

I. JUNIOR COLLEGE COURSES (1–4).

1. **Popular Lectures.**

3. **Descriptive Astronomy.**—An elementary course, dealing with fundamental facts, principles, and methods. Mj. Summer Quarter; 7:30.
Mj. Spring Quarter; 8:30.
DR. MOULTON.
Prerequisite: *College Algebra, and the Elements of Physics.*

II. SENIOR COLLEGE COURSES (5–20).

5, 6. **Analytic Mechanics.**—Two consecutive quarters. An introductory course based on Bowser's *Analytic Mechanics*, supplemented by lectures.
Mj. Autumn Quarter; 2:00.
Mj. Winter Quarter; 2:00.
DR. MOULTON.
Prerequisite: *Differential and Integral Calculus.*

7. **Spherical and Practical Astronomy I.**—Spherical Trignometry and its application to Astronomy. The various systems of spherical co-ordinates. Time. Parallax, Refraction, Aberration, Precession, Nutation, and Proper Motion.
Mj. Winter Quarter; 11:00.
ASSISTANT PROFESSOR LAVES.
Prerequisite: *XVII, 1–3.*

8. **Spherical and Practical Astronomy II.**—The theory of instruments with practical applications; the corrections of observations and the use of star catalogues.
Mj. Spring Quarter; 11:00.
ASSISTANT PROFESSOR LAVES.
Prerequisite: *Course 7.*

9. **Observatory Work.**—Practice with the Equatorial and with the Universal Instrument in the Students' Observatory. Mj. Summer Quarter.
ASSISTANT PROFESSOR LAVES.
Prerequisite: *Courses 3 and XVII, 1–2.*

10. **Astronomical Optics.**—An introductory course to the theory of dioptrics as applied to astronomical instruments. Mj. Autumn Quarter; 3:00.
DR. MOULTON.
Prerequisite: *Plane Analytics.*

III. GRADUATE COURSES (21–50).

22. **Introduction to Celestial Mechanics I.**—Central forces; demonstration of law of gravitation; problem of two bodies; the ten integrals of planetary motion; considerations on perturbations; Helmholtz theory of the heat of the sun.
Mj. Winter Quarter; 12:00.
ASSISTANT PROFESSOR LAVES.
Prerequisite: *Calculus.*

23. **Introduction to Celestial Mechanics II** (Determination of Orbits and Special Perturbations).—Properties of conic section motion; determination of two geocentric distances from the observations; determination of elements, and methods of improving them; variations of elements; perturbations of rectangular and polar coördinates; numerical differentiation and integration. Mj. Spring Quarter; 12:00.
ASSISTANT PROFESSOR LAVES.

23A. **The Construction of Astronomical Ephemerides.**—A short outline of the theory of orbits and perturbations, sufficient to enable the student to understand Le Verrier's and Newcomb's planetary tables, which will be studied in detail.
Mj. Summer Quarter; 9:30.
ASSISTANT PROFESSOR LAVES.
Prerequisite: *Calculus.*

24. **The Problem of Three Bodies.**—Motion of an infinitesimal body; surfaces of zero relative velocity; particular solutions; case of three finite bodies; generalizations to four and more bodies. Lagrange's and Jacobi's reductions of the order of the problem.
Mj. Summer Quarter; 8:30.
DR. MOULTON.
Prerequisite: *Calculus.*

25. **Dynamics of a System of Bodies.**—Lagrange's differential equations of the second kind, Hamilton's differential equations. The study of the partial differential equation of Hamilton-Jacobi and the properties of the integral equations Further investigations of A. Mayer, Sophus Lie, and H. Poincaré.
Mj. Spring Quarter; 2:00.
DR. MOULTON.
Prerequisite: *Courses 5, 6.*

34. **Absolute Perturbations I.**—The theory of variation of constants applied to the problem of three bodies. Le Verrier's expressions for the general perturbations of the elements. Secular perturbations after Laplace's method.

Mj. Winter Quarter; 3:00.
Dr. Moulton.

Prerequisite: *Courses 22, 23.*

Courses 3, 5, 6, 7, 8, 22, and 23 are repeated annually. The other courses are given in intervals of two or three years. For general direction the following courses are mentioned, which were given during the last two or three years and which will reoccur in the announcements in due time; viz.:

Course 35. Absolute Perturbations II (theory of Hansen).

Course 36. Absolute Perturbations III (theories of Gyldén, Bohlin).

Course 38. Modern Theories of Celestial Mechanics I (Poincaré's investigations).

Course 39. Modern Theories of Celestial Mechanics II (Poincaré's investigations).

Course 40. Theory of Satellites of Jupiter and Saturn.

Course 42. Attractions and Figures of the Heavenly Bodies.

At the Yerkes Observatory.

In the work at the Yerkes Observatory the advanced student is made familiar with modern methods of research in various branches of Practical Astronomy and Astrophysics. In general, the work in progress during the year 1902–3 will probably include: researches in solar physics with the spectroscope, spectroheliograph, photoheliograph, and radiometer; micrometric observations of double stars, planets, satellites, nebulæ, and comets; photographic studies of stellar spectra and determination of motion in the line of sight; photography of star clusters, nebulæ, etc.; photographic investigations of stellar parallax; special astrophysical researches. On account of the nature of the Observatory's work, it is possible that the subjoined outline of courses will require some modification. Graduate students wishing to take any of the courses should consult the Director of the Yerkes Observatory, Williams Bay, Wis., before making a selection.

Hours are to be arranged with the instructor.

GRADUATE COURSES.

51. **Astronomical Spectroscopy.**—This is a general course on the applications of the spectroscope in astronomy, with practical work. Mj.
Professor Frost.

Prerequisite: *Practical Astronomy, Advanced Physics and Laboratory Practice, Spectrum Analysis.*

52, 53, 54, 55. **Solar Physics.**—This course includes systematic observational work with the telescope and spectroscope, supplemented by constant reference to the literature of the subject.

52. Visual and photographic study of the solar photosphere, spots, and faculæ. Use of the photoheliograph. DMj. Summer Quarter.

53. Visual and photographic observations of the chromosphere, prominences, faculæ, and spots with the solar spectroscope and spectroheliograph. DMj. Autumn Quarter.

54. Measurement and reduction of photographs made with the solar spectrograph, photoheliograph, and spectroheliograph.
DMj. Winter Quarter.

55. Spectroscopic observations of sun-spots, including the systematic study of widened lines. DMj. Spring Quarter.
Professor Hale.

Prerequisites: Same as for *Astronomical Spectroscopy.*

56, 57. **Stellar Spectroscopy.**— These courses, like the preceding ones, consist of systematic observational work combined with a constant study of original memoirs. In both courses the student will assist in making and in measuring photographs of stellar spectra.

56. (1) A visual and photographic study of stellar spectra, with special reference to stars of Secchi's Fourth Type.
3DMj. Autumn, Winter, and Spring Quarters. Professor Hale.

57. (2) The photographic determination of stellar motions in the line of sight.
DMj. Summer Quarter.
2DMj. Autumn and Spring Quarters.
Professor Frost.

58. **Celestial Photometry.**—A course dealing mainly with the theoretical principles, and based upon Müller's *Photometrie der Gestirne*.

Mj. Autumn Quarter.
PROFESSOR FROST.

59. **Astronomical and Astrophysical Research.**—Students qualified for research will be given opportunity for special investigations in Astronomy and Astrophysics.

PROFESSORS HALE, BARNARD, AND FROST.

THE YERKES ASTRONOMICAL OBSERVATORY.

OFFICERS OF GOVERNMENT.

GEORGE ELLERY HALE, *Professor of Astrophysics, and Director.*
SHERBURNE WESLEY BURNHAM, *Professor of Practical Astronomy, and Astronomer.*
EDWARD EMERSON BARNARD, *Professor of Practical Astronomy, and Astronomer.*
EDWIN BRANT FROST, *Professor of Astrophysics, and Astrophysicist.*
GEORGE WILLIS RITCHEY, *Instructor in Practical Astronomy and Superintendent of Instrument Construction.*
FERDINAND ELLERMAN, *Instructor in Astrophysics.*
STORRS BARROWS BARRETT, *Secretary and Librarian.*
WALTER SIDNEY ADAMS, *Assistant.*
JOHN ADELBERT PARKHURST, *Assistant.*
NORTON ADAMS KENT, *Assistant.*

J. A. JOHANNESEN, *Instrument Maker.*
F. R. SULLIVAN, *Engineer in Charge of 40-Inch Telescope.*

HERMANN A. FISCHER, A.M. (Professor of Mathematics and Astronomy, Wheaton College), *Volunteer Research Assistant* (Summer Quarter, 1901).
CHARLES E. ST. JOHN, PH.D. (Professor of Physics, Oberlin College), *Volunteer Research Assistant* (Summer Quarter, 1901).

THE OBSERVATORY.

The Yerkes Observatory was founded in 1892, through the munificence of Mr. Charles T. Yerkes, of Chicago. Its principal instrument is a refracting telescope of 40 inches' aperture, which is provided with the following attachments:

1. A position micrometer.
2. A wedge photometer.
3. A double-slide plate-holder, with color screen, for direct photography of the sun, moon, stars, nebulæ, etc.
4. A solar spectrograph, for micrometrical and photographic investigations of the spectra of solar phenomena.
5. A spectroheliograph, for photographing the solar chromosphere, prominences, and faculæ by monochromatic light.
6. A stellar spectrograph, for researches on the spectra and motions of stars, nebulæ, comets, and planets.

The construction of the main building of the Observatory was completed in 1897. Its form is that of a Latin cross, with three domes and a meridian room at the extremities. The principal axis (about 330 feet long) of the building lies east and west, with the dome for the 40-inch telescope at the western end. This dome is 90 feet in diameter, allowing ample space for the tube of the great telescope, which, with its attachments, is nearly 70 feet long. The elevating floor of the observing room is 75 feet in diameter, and is movable through a range of 23 feet by means of electric motors.

Of the two smaller domes, the one to the northeast contains the 12-inch telescope formerly at the Kenwood Observatory, and in the other is mounted a 24-inch reflector. Between these domes is the heliostat room, 100 feet long by 12 feet wide. A large heliostat stands on a pier at the north end of the room, under an iron roof, which can be rolled away to the south.

The meridian room has double sheet-iron walls, with an intervening air space. It is designed to contain a meridian circle of large aperture, but for the present a transit instrument suffices for the purposes of the Observatory.

The body of the building is divided through the center by a hallway extending from the meridian room to the great tower. On either side are offices and computing rooms, a library, lecture-room, two spectroscopic laboratories, dark room, developing rooms, galvanometer room, chemical laboratory, instrument rooms, etc. In the basement is a large photographic dark room, an enlarging room, concave grating room with large concave grating spectroscope, emulsion room, constant temperature room, physical laboratory, and optician's room. The engines, dynamos, and boilers for supplying heat and power are in the power-house at a distance of several hundred feet from the Observatory.

Much of the special apparatus needed for the researches conducted at the Observatory is constructed by the mechanicians under the supervision of Mr. Ritchey. For this purpose a large workshop has been provided, equipped with a complete outfit of instrument-maker's tools, including an 8-inch Rivett precision lathe, Blaisdell engine lathe, Brown & Sharpe universal milling machine, planer, drill-press, shaper, circular saw, speed-lathe, etc.

The Observatory is situated about a mile from the town of Williams Bay, near Lake Geneva, Wisconsin, in an ideal rural region, free from the dust and smoke of cities and removed from the tremors of railroad traffic. Lake Geneva is about seventy-five miles from Chicago, and is reached by a branch of the North-Western Railroad. The site of the Observatory includes about fifty acres of wooded land fronting on the lake.

OPPORTUNITIES FOR STUDENTS.

Advanced students in Astronomy and Astrophysics are offered every possible opportunity to profit by the instrumental facilities of the Yerkes Observatory. In addition to the regular courses of instruction, opportunities to take part in the investigations in progress at the Observatory are freely accorded to all students who are qualified for such work. As soon as capacity for original research has been sufficiently developed, students are encouraged to undertake investigations of their own.

SPECIAL INVESTIGATORS.

The facilities enjoyed at the Yerkes Observatory for the prosecution of special researches in various fields of Astronomy and Astrophysics are in some cases of an exceptional nature. It has accordingly been felt that, so far as this can be done without interfering with the regular work of the members of the staff, opportunity should be given to men of science connected with other institutions to carry on special investigations at the Observatory. The Director has been authorized to extend invitations to undertake such special work to those who may seem likely to make good use of the opportunities thus afforded.

VOLUNTEER RESEARCH ASSISTANTS.

It may not infrequently be the case that students who have taken higher degrees in Astronomy, Astrophysics, or Physics, or have completed advanced studies in these subjects at the University of Chicago or some other institution, will find it to their advantage to spend some time at the Yerkes Observatory, in order to familiarize themselves with its work. To meet this need the position of Volunteer Research Assistant has been established. Those who are appointed to this position are expected to carry on such work as may be assigned to them during their connection with the Observatory. They receive no pay for their services, but are given every reasonable opportunity to become acquainted with the investigations in progress, and in some cases to conduct researches of their own.

PUBLICATIONS OF THE OBSERVATORY.

The publications of the Observatory include: *Bulletins of the Yerkes Observatory*, containing announcements of results and discoveries, brief descriptions of new buildings and instruments, and notes on the work of the Observatory; *Contributions from the Yerkes Observatory*, consisting of papers contributed to various astronomical and astrophysical periodicals and the proceedings of societies; *Publications of the Yerkes Observatory*, in the form of quarto volumes containing detailed accounts of special researches (Vol. I, A General Catalogue of 1290 Double Stars, discovered by S. W. Burnham, has recently been published); and *The Astrophysical Journal*, an International Review of Spectroscopy and Astronomical Physics, now in its fifteenth volume.

OBSERVATORY LIBRARY.

The library contains sets of many of the astronomical periodicals, charts, star catalogues, annals of observatories, and numerous general works.

The University will be glad to answer inquiries from institutions looking for well-equipped teachers in Mathematics, and of Astronomy and Astrophysics.

Letters of inquiry and requests for documents should be addressed to

THE UNIVERSITY OF CHICAGO,
Chicago, Ill.

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1903-04

The University of Chicago
FOUNDED BY JOHN D. ROCKEFELLER

THE LIBRARY
OF THE
UNIVERSITY OF ILLINOIS

PROGRAMME

OF THE DEPARTMENTS OF

PHYSICS AND CHEMISTRY

1903-1904

CHICAGO
The University of Chicago Press
1903

See Chemistry

THE RYERSON PHYSICAL LABORATORY.

OFFICERS OF GOVERNMENT.

ALBERT ABRAHAM MICHELSON, *Professor and Head of the Department of Physics.*
SAMUEL WESLEY STRATTON, *Professor of Physics.*
ROBERT ANDREWS MILLIKAN, *Assistant Professor of Physics.*
CHARLES RIBORG MANN, *Assistant Professor of Physics.*
CARL KINSLEY, *Assistant Professor of Physics.*
GLENN MOODY HOBBS, *Instructor in Physics.*
HENRY GORDON GALE, *Instructor in Physics.*
CHARLES ALBERT PROCTOR, *Research Assistant in Physics.*

A. DE KHOTINSKY, *Instrument Maker.*
JULIUS PEARSON, *Assistant Instrument Maker.*

THE BUILDING.

The Ryerson Physical Laboratory was completed Jan. 1, 1894. In the design and construction of this building no element of utility has been omitted, and every effort was made to include all the desirable features of a first-class Physical Laboratory.

All the walls and floors are strong and heavy; the laboratories on the first floor are provided with piers of masonry, in addition to the heavy slate wall-shelves which are found throughout the building. Every laboratory is provided with gas for light or fuel, electricity for light and power, water, compressed air, and vacuum pipes.

The laboratories are also equipped with a system of heating apparatus which may be used as a direct or an indirect system, and is controlled automatically by the most improved form of temperature regulators. Ducts and channels have been provided between the walls and in the floor, so that pipes or wires may be laid from one part of the building to another without difficulty.

The space in the building has been utilized as follows: Rooms for special purposes, small laboratories for work of investigation, large laboratories for general instruction, lecture rooms, class rooms, library, and offices.

The first floor is devoted to laboratories for research work, two large constant-temperature rooms, and the mechanician's room which is fitted up with all the tools and appliances necessary in the construction and repair of physical apparatus. The rooms of the west wing are free from iron and are devoted to the work in electricity and magnetism.

On the second floor are found a large general laboratory for advanced undergraduate work, optical laboratories, a chemical laboratory, a large dark room, two developing rooms, and the large lecture hall with its adjoining apparatus and preparation rooms. The offices of the Director and of the faculty are also on this floor.

The third floor is devoted to a general laboratory for the undergraduate work in general physics, which with its adjoining apparatus and preparation rooms occupies the entire floor of the east wing. On the same floor are found two general laboratories and class rooms.

The central part of the fourth floor forms a hall for experiments requiring a large space. The roof above this portion is flat and suitable for observations in the open air.

A shaft has also been provided for pressure-gauges and for experiments requiring a greater vertical distance than is found in the laboratories.

Recent investigations have shown that the location of the Ryerson Laboratory is an exceedingly good one, and that the outside disturbances which are usually so annoying are at a minimum.

XIX. THE DEPARTMENT OF PHYSICS.

OFFICERS OF INSTRUCTION.

ALBERT ABRAHAM MICHELSON, Ph.D., Sc.D., LL.D., F.R.S., etc., *Professor and Head of the Department of Physics.*
SAMUEL WESLEY STRATTON, S.B., *Professor of Physics.*
CHARLES RIBORG MANN, Ph.D., *Assistant Professor of Physics.*
ROBERT ANDREWS MILLIKAN, Ph.D., *Assistant Professor of Physics.*
CARL KINSLEY, A.M., M.E., *Assistant Professor of Physics.*
GLENN MOODY HOBBS, S.B., *Instructor in Physics.*
HENRY GORDON GALE, Ph.D., *Instructor in Physics.*
CHARLES ALBERT PROCTOR, A.B., *Research Assistant in Physics.*

FRANK BALDWIN JEWETT, Ph.D., *Research Assistant in Physics* (Summer Quarter, 1903).

FELLOWS.

1903-1904.

THOMAS DOUBT, S.B., A.M.
ARTHUR GRANT STILLHAMER, S.B., A.M.
EVELYN SHEWELL HAYDEN, S.B.

A. de KHOTINSKI, *Mechanician.*
JULIUS PEARSON, *Assistant Mechanician.*

INTRODUCTORY.

Within the last twenty years the teaching and practice of Physics has undergone a revolution more complete than that of any of its sister sciences. This result may be attributed, to a very great extent, to the enormous development of its applications to electrical industries. No other industrial application since the invention of the steam-engine has so enhanced the appreciation of the importance of exact knowledge, or given a greater impetus to the search for new truths in the unexplored regions on the borderland of science.

So closely interwoven are the advances in pure science and its applications that it is difficult to say which has been of greater service to the other, but it is evident that it is as ill-advised to ignore the powerful stimulus furnished by the practical development of scientific ideas as it is to belittle the influence which theoretical and experimental science have had on the world's material prosperity.

While it is never safe to affirm that the future of Physical Science has no marvels in store even more astonishing than those of the past, it seems probable that most of the grand underlying principles have been firmly established, and that further advances are to be sought chiefly in the rigorous application of these principles to all the phenomena which come under our notice.

It is here that the science of measurement shows its importance—where quantitative results are more to be desired than qualitative work. An eminent physicist has remarked that the future truths of Physical Science are to be looked for in the sixth place of decimals.

In order to make such work possible, the student and investigator must have at his disposal the methods and results of his predecessors, must know how to gauge them, and to apply them to his own work; and especially must he have at his command all the modern appliances and instruments of precision which constitute a well-equipped laboratory—without which results of real value can be obtained only at immense sacrifice of time and labor.

The science of Astronomy appeals far more powerfully to most people than does Physical Science, which, indeed, to many is scarcely known even by name. The former is as old as history. Its wonders have compelled the attention of mankind from the earliest ages, and it is but a natural consequence that at the present day no important city in the civilized world is without a richly endowed observatory, where a trained corps of astronomers are able to study the phenomena of the life of suns and worlds, and their distribution in time and space.

It is only in very recent times that it has begun to dawn upon the mind of man that there is another world only one degree less complex and wonderful than the stellar universe — the world of molecules and atoms. For the study of these almost infinitesimal systems of pigmy stars we have no telescope nor even microscope to help us; but little by little we are constructing a powerful logical engine which is destined one day to bring the revolutions, rotations, and oscillations of these minute orbs as clearly to the mind's eye as are now the motions of the worlds of the greater, visible universe.

It may be said that this is, in fact, our chief problem—the constitution of matter; and while ultimately this is, and must always be, beyond the scope of our powers, it is as legitimate and worthy an object to extend our knowledge step by step in this direction as to increase our knowledge of the structure of the sidereal universe, even though this can never be completely fathomed.

As in the case of Astronomical observatories the work, while chiefly devoted to furthering the interests of pure science, is nevertheless consistent with the furnishing of valuable information of immediate practical utility, so a Research Laboratory, while carefully preserving its chief and essential feature, may be still practically useful in furnishing authoritative measurements of standards of length, mass, and time, calibration of thermometers, pressure-gauges, comparison of standards, of resistance, electro-motive force, capacity, self-induction, etc.

It is hoped that this outline of the aims and ends of a Physical Research Laboratory, partial and incomplete though it be, may justify the hope and belief that the generosity of the founder of the University and the donor of the Ryerson Physical Laboratory will be supplemented by many other liberally minded men, equally disposed to further so worthy a cause.

In the enthusiasm which inevitably accompanies the work of the investigator, that of the instructor will not be ignored; indeed, it is confidently expected that these two functions will mutually assist each other.

The courses of instruction to be given in the Department of Physics, it is believed, are sufficiently varied to suit the requirements of all classes, including those who desire simply to complete a general education, or to undertake the subject as a disciplinary study; those who wish to pursue it as a preliminary to its application to mechanical, electrical, or civil engineering; or those who intend to make it their life-work.

In each case every opportunity will be taken to present the subject in such a way as to impress the student with the reality of the principles and laws expounded by well-chosen experiments, performed by the instructor and whenever possible by the student himself.

A feature on which considerable stress will be laid is the repetition of the classical experiments of eminent investigators by those graduate students who are able to undertake them.

It is believed that by this means a great deal of valuable experience will be gained, without the vexatious annoyances encountered in entering upon an original investigation, before having the benefit of such preliminary training.

For a description of the Ryerson Physical Laboratory, see p. 2 of this PROGRAMME.

FELLOWSHIPS AND GRADUATE SCHOLARSHIPS.

The University appoints each year a limited number of Fellowships and Graduate Scholarships. Detailed information concerning these and the conditions of their appointment are found on pp. 81 and 82 of the *Annual Register* of 1902-3.

COURSES OF INSTRUCTION.

Summer Quarter, 1903—Spring Quarter, 1904.

M=Minor course=a single course for six weeks. DM=Double Minor course=a double course (two hours daily) for six weeks. Mj=Major course=a single course for twelve weeks. DMj=Double Major course=a double course (two exercises daily) for welve weeks.

JUNIOR COLLEGE COURSES.

Elementary Physics. — A first course in the elements of Physics. (See prerequisite to Course 1.)

Mj. Autumn Quarter, 9:30.
DR. GALE.

Continued. Mj. Winter Quarter, 9:30.
DR. GALB.

1. **General Physics.**—A general course in mechanics, molecular physics, and heat, presented mainly from the experimental standpoint.

10 hrs. a week. Mj. Every Quarter.
Summer Quarter; 8:30-10:30.
MR. HOBBS.
11:00-1:00.
DR. GALB.

Autumn Quarter; 8:30–10:30; 11:00–1:00.
ASSISTANT PROFESSOR MANN.
Winter Quarter; 11:00–1:00.
MR. HOBBS.
Spring Quarter; 8:30–10:30.
ASSISTANT PROFESSOR KINSLEY.

Prerequisite: *Entrance Physics*, or *both Majors of Course 0 and Plane Trigonometry.*

2. **General Physics.**—A continuation of Course 1 covering the subjects of electricity and light.
10 hrs. a week. Mj. Summer Quarter; 2:00–4:00. ASSISTANT PROFESSOR MILLIKAN.
Mj. Winter Quarter, 8:30–10:30.
ASSISTANT PROFESSORS MILLIKAN AND KINSLEY.

Prerequisite: *General Physics 1.*

3. **General Physics.**—A course of lectures and demonstrations intended to complete a year's work in Junior College Physics. The most important principles of Physics not treated in Courses 1 and 2 are presented from the lecture standpoint.
5 hrs. a week. Mj. Summer Quarter; 9:30.
ASSISTANT PROFESSOR MILLIKAN.
Mj. Spring Quarter; 9:30.
ASSISTANT PROFESSOR MANN
with occasional lectures by
PROFESSOR MICHELSON.

Prerequisite: *General Physics 1.*

SENIOR COLLEGE COURSES.

11. **Molecular Physics and Heat.** — A lecture course for advanced and graduate students, covering the Kinetic Theory, Capillarity, Elementary Thermodynamics, Solution, Electrolysis, and the Electron Theory.
Mj. Spring Quarter; 11:00.
ASSISTANT PROFESSOR MILLIKAN.

Prerequisite: *General Physics, 1, 2, and 3. Differential and Integral Calculus.*

12. **Sound and Light.**—A lecture course for advanced and graduate students covering the subjects of sound, music and the more important sections of geometrical and physical optics.
5 hrs. a week. Mj. Winter Quarter; 11:00.
ASSISTANT PROFESSOR MANN.

Prerequisite: *Differential and Integral Calculus, Physics 1, 2, and 3.*

13. **Electricity and Magnetism.** —A course of advanced work in theoretical Electricity and Magnetism, intended to supplement the work in General Physics or prepare for the graduate work.
5 hrs. a week. Mj. Autumn Quarter; 11:00.
ASSISTANT PROFESSOR KINSLEY.

Prerequisite: *Differential and Integral Calculus, Physics 1, 2, and 3.*

16. **Experimental Physics** (Advanced). — Molecular Physics and Heat. — A course of advanced laboratory work involving the determination of vapor pressures and densities, co-efficients of friction of gases and liquids, molecular electrical conductivities, freezing and boiling points, latent and specific heats, etc.
10 hrs. a week. Mj. Spring Quarter; 2:00–4:00. ASSISTANT PROFESSOR MILLIKAN AND MR. HOBBS.

Prerequisite: *Differential and Integral Calculus, Physics 1, 2, and 3.*

17. **Experimental Physics** (Advanced). — *Light.* — A course of advanced laboratory work in Light, consisting of accurate measurements in diffraction, dispersion, interference, and polarization.
10 hrs. a week. Mj. Summer Quarter; 2:00–4:00. Mj. Winter Quarter; 2:00–4:00.
DR. GALE.

Prerequisite: *Differential and Integral Calculus, Physics 1, 2, and 3.*

18. **Experimental Physics** (Advanced). — *Electricity and Magnetism.*—Laboratory work of the same grade as Courses 16 and 17, but consisting of measurements in Electricity and Magnetism.
10 hrs. a week. Mj. Summer Quarter; 2:00–4:00. ASSISTANT PROFESSOR KINSLEY.
Mj. Autumn Quarter; 2:00–4:00.
ASSISTANT PROFESSOR KINSLEY.

Prerequisite: *Differential and Integral Calculus, Physics 1, 2, and 3.*

20. **Physical Manipulation.** — A series of exercises not provided for in the regular courses of Experimental Physics, but exceedingly important to the teacher or advanced student consisting of the following groups:

Group A. *Shop Work* includes the cutting, filling, drilling, tapping, soldering, and polishing of metal, screw cutting, and elementary lathe work.

Group B. *Glass Work* includes the cutting, grinding, drilling, polishing, and testing of glass.

Group C. *Glass Blowing* includes the simpler processes in glass blowing, such as cutting, bending, and joining of tubes, blowing bulbs, sealing in electrodes, etc.

Group D. *Chemical Processes and Physical Preparations* includes the silvering of glass, cleaning and distillation of mercury, preparation of fibers for suspension, and materials useful in experimental work.

10 hrs. a week. Mj. Summer Quarter; 11:00–1:00. MR. HOBBS.

NOTE. — Mr. Hobbs will be assisted, during the Summer Quarter, by specialists in Groups A, B, and C. A laboratory fee of $5.00 will be charged for this course. Groups B and C will be given in the First Term only.

Mj. Winter Quarter; 11:00–1:00.
MR. HOBBS.

Prerequisite: *Physics 1, 2, and 3.*

24. **Mechanical Drawing.** — A course designed to acquaint the student with the principles of mechanical drawing and projection, the preparation of working sketches and drawings, and elementary curve tracing.

10 hrs. a week. Mj. Summer Quarter; 10:30–12:30. DR. JEWETT.

Mj. Spring Quarter; 3:00–5:00.
MR. HOBBS.

GRADUATE COURSES.

31. **Theoretical Physics.**— A series of lectures, chiefly in Theoretical Physics. Hydrodynamics, Elasticity, Capillarity, Molecular Physics, Thermodynamics, Wave-motion and Sound. Optical Theories, Electricity and Magnetism, 4 hrs. a week.

Mj. Autumn Quarter; 12:00.
Mj. Winter Quarter; 12:00.
Mj. Spring Quarter; 12:00.
PROFESSOR MICHELSON.

Prerequisite: *Physics 11, 12 and 13.*

32. **Experimental Physics.** — A course of laboratory work, chiefly devoted to the repetition of classical experiments, such as: Determination of the Mechanical Equivalent of Heat, Maxwell's "V" Hertzian Oscillation, Relative and Absolute Wave-lengths, etc.

10 hrs. a week. Mj.

Autumn, Winter, Spring Quarters.
PROFESSOR MICHELSON.

Prerequisite: *Physics, 16, 17, and 18.*

33. **Research Course.** — This course is intended for those graduate students who are prepared to undertake special research.

Except in the case of a purely mathematical problem, the entire time is to be devoted to work in the laboratory.

20 hrs. a week. Every Quarter.

DMj. Summer Quarter.
ASSISTANT PROFESSOR MILLIKAN.

3DMj. Autumn, Winter, and Spring Quarters.
PROFESSOR MICHELSON.

36. **Thermodynamics.** — Lectures upon the fundamental principles underlying the mechanical theory of heat and the application of these principles to physical and thermochemical problems.

5 hrs. a week. Mj. Winter Quarter; 3:00.
ASSISTANT PROFESSOR MILLIKAN.

37. **Introduction to Mathematical Physics.**

Mj. Autumn Quarter; 11:00.
DR. GALE.

38. **Experimental Electricity.**— A laboratory course in practical electricity involving a study of dynamos, motors, and transformers. 10 hrs. a week.

Mj. Summer Quarter; 3:00–5:00.
Mj. Winter Quarter; 2:00–4:00.
ASSISTANT PROFESSOR KINSLEY.

39. **Electric Waves.**—A discussion of the theory of the generation and detection of electric waves, of stationary waves on wires, and of electric resonance. 5 hrs. a week.

½Mj. Summer Quarter; 2:00.
Mj. Spring Quarter; 9:30.
ASSISTANT PROFESSOR KINSLEY.

40. **Seminar:** *History of the Development of Physical Ideas.*

3Mj. Autumn, Winter, and Spring Quarters; 4:00. ASSISTANT PROFESSOR MANN.

41. **History of Physics.**—A discussion of the growth of physical theories. Open to undergraduates.

5 hrs. a week. Mj. Winter Quarter; 2:00.
ASSISTANT PROFESSOR MANN.

42. **The Theory of Alternating Currents.**

½Mj. Summer Quarter; 2:00.
DR. JEWETT.

XX. THE DEPARTMENT OF CHEMISTRY.

OFFICERS OF INSTRUCTION.

JOHN ULRIC NEF, PH.D. *Professor and Head of the Department of Chemistry.*
ALEXANDER SMITH, PH.D., *Associate Professor of General Chemistry.*
JULIUS STIEGLITZ, PH.D., *Associate Professor of Chemistry.*
HERBERT NEWBY McCOY, PH.D., *Assistant Professor of Physical Chemistry.*
JOHN C. HESSLER, PH.D., *Instructor in Chemistry.*
LAUDER W. JONES, PH.D., *Instructor in Analytical Chemistry.*
WILLIS B. HOLMES, PH.D., *Associate in Chemistry.*
——— ———, *Research Assistant in Chemistry.*
IRA HARRIS DERBY, S.B., *Assistant in Quantitative Analysis.*
ROY HUTCHINSON BROWNLEE, A.B., *Lecture Assistant in Chemistry.*
RICHARD BLAIR EARLE, Sc.D., *Research Assistant in Chemistry.*
WALTER FULLER, *Laboratory Inspector.*

HORACE G. BYERS, PH.D., *Professor of Chemistry, University of Washington* (Summer Quarter, 1903).

WALTER STANLEY HAINES, A.M., M.D., *Professor of Chemistry, Pharmacy, and Toxicology, Rush Medical College; Professorial Lecturer on Toxicology.*

FELLOWS.

1903-1904.

RAYMOND BACON, S.B., A.M.
HENRY GRANGER KNIGHT, A.B.
HERMANN IRVING SHLESINGER, S.B.
OSWIN W. WILLCOX, S.B., *Loewenthal Fellow.*

INTRODUCTORY.

The work of the department is divided between research and instruction, in both of which every officer takes part.

Research.—Research Students in the University, or coming from other institutions, are encouraged to begin research if, and as soon as, their preparation justifies it. Facilities for research in all lines, whether of inorganic, organic, or physical chemistry, are provided.

Special opportunities to pursue entirely independent research work will be given to maturer students who have already obtained the doctor's degree.

Instruction.—The objects of the instruction are to prepare students, (1) to teach in colleges or universities, (2) to teach in secondary schools (3) to fill positions as technical experts or assistants in chemical industries, (4) to become analysts in commercial or sanitary laboratories. The elementary courses may be taken with advantage by students having none of these ends in view.

The courses from which students of the above classes select their work include: General Chemistry, four and one-half Majors and Research; Analytical Chemistry, eleven and one-half Majors; Organic Chemistry, nine and one-half Majors and Research; Inorganic Chemistry, seven Majors and Research; Physical Chemistry, five Majors and Research; Teaching of Chemistry, History of Chemistry, and Club meetings.

Special stress will be placed on thorough preparation and symmetrical development of the student's knowledge. The object of the courses will be not so much to train specialists as to prepare the student to undertake intelligently any and every kind of work of a chemical nature. Those intending to become practical chemists will find a thorough course of purely scientific chemistry the best basis for future specialization in any direction whatever. Those who incline towards inorganic chemistry will be required to do much physical and a considerable amount of organic work; those proposing to become organic chemists will be required to do work in inorganic chemistry of a more advanced nature than that given in the elementary and analytical courses, and some physical chemistry, and so forth.

REQUIREMENTS FOR HIGHER DEGREES.

The Degree of Ph.D.: Chemistry as Major Subject.—The requirements for the degree of Doctor of Philosophy (for general University regulations, see the *Annual Register*, 1902–3, p. 81) are:

1) The presentation of a thesis embodying the result of original research in general inorganic, organic, physico-organic, or physical chemistry. This must constitute a real contribution to knowledge, and the work is usually done under the direction of an officer of the department.

2) Specially thorough and mature knowledge of the branches of chemistry touched by the thesis, and less thorough but sufficient knowledge of other fundamental branches of the science.

The General Requirements* for all candidates are as follows: Courses 1–3 (or 1A, 2A), 4†, 6–10, 28A, 28B, and two Majors selected from Courses 11, 13A–13G, 14–16; total twelve Majors, of which eight Majors are undergraduate work.

Special requirements* in addition to the above, arranged according to the thesis subject, are as follows:

General Chemistry: Courses 25–27, 20 or 31, and one Major taken from Courses 13, 19, 21, 22, 29–32; total five Majors.

Organic Chemistry: Courses 20–22, 25, and one Major from 10, 13, 19, 26, 27, 29–32; total five Majors.

Physico-Organic Chemistry: Courses 20, 21, 25, and 22 or 31, and one Major taken from Courses 10, 13, 19, 26, 27, 29–32; total five Majors.

Physical Chemistry: Courses 25, 26, 31, 32, and one Major taken from Courses 10, 13, 19, 20–22, 27; total five Majors.

In addition to one set of these specific requirements*, at least six half Majors will be chosen from the special lecture courses, 23, 29, 30, 34–38, 40, 42. The research work will require from four to six Quarters.

3) Sufficient work in one or two minor subjects. For instance, if Physics is a minor subject, at least two years of College Physics, Courses 1, 2, 3, and three of the Courses 11, 12, 13, 16, 17, 18. Mineralogy and crystallography (about 1½ Majors) are required of all candidates, in addition to the regular minor subject.

4) A reading knowledge of French and German is required of candidates for higher degrees.

The Degree of Ph.D.: Chemistry as Secondary Subject.—When chemistry is a secondary subject, the requirement is determined after conference with the Head of the Department in which the major work is done. In the past it has consisted of Courses 1, 2, 3, 6, 7, 8, or their equivalent, together with elementary physical chemistry (28A and 28B) or organic chemistry, according as the major subject belonged to the physical or the biological group.

The Master's Degree.—For the specialist Master's degree a dissertation and seven Majors of graduate work in chemistry are required. These must be selected from Courses 10 to 42, with the approval of the Head of the Department. Courses prerequisite to these must be taken, but cannot be counted in reckoning the seven required Majors. For the non-specialist degree the selection may be made from Courses 8 to 42, with the approval of the Heads of the three Departments concerned.

PREPARATION FOR TEACHING AND TECHNICAL POSITIONS.

For Teaching.—While the Department does not usually recommend for college or university positions students who have not taken the work required for the doctor's or master's degree, the degree of bachelor, with a sufficient amount of work in chemistry is at present considered preparation for teaching in secondary schools.

In general the work in chemistry should include Courses 1, 2, 3, 4, 6, 7, 8, 28A, 28B, and 40, or their equivalent, as well as work in the College of Education (*cf.* pp. 129 ff. of the *Annual Register*, 1902–3). The latter is given by the College of Education in connection with the University High School, and opportunities are also offered for giving laboratory instruction in the elementary classes of the University. The prospective teacher should secure preparation to teach at least one science besides chemistry.

For Technical Positions.—The department meets the demand for work which will prepare men for careers in technical chemistry in three directions:

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*It is understood that the requirement may be satisfied by equivalent work done in other institutions of high standing. At least four and a half quarters of resident graduate work must usually be taken in the University of Chicago.

†Course 4 may be omitted when advanced lecture and laboratory work in Organic Chemistry is taken.

1. The thorough scientific training in all branches of chemistry required for the attainment of the Ph.D. degree forms the best basis for a future career as a chemical expert in any branch of chemical industry. With this preparation, the principles and details of technical processes are quickly grasped, advances in industrial processes under the influence of new discoveries in inorganic, organic, physical, or analytical chemistry are intelligently followed, and newly discovered principles are readily applied to any branch of technical work.

2. Students who have taken from 10 to 15 Majors of work in the department are able, after graduation, to obtain and to fill satisfactorily positions as assistants in technical and analytical laboratories, and after some practical experience to advance to positions of independent responsibility. Students intending to enter on such a career and intending to fill an assistant's position, should take at least Courses 1 to 10 inclusive, and one or two Majors in Courses 13A–13G. If possible, Courses 28A and 28B and, according to the choice of work in Organic or Inorganic Chemistry, two or three courses selected from Nos. 12. 14–16, 20–22, 25–27 should be taken in the interest of a broader and more thorough preparation. Students taking such a preparation are given the preference in answering requests received by the Department. Students taking the less complete training mentioned above, however, are also sought by technical firms.

3. The Department gives, with other departments (notably Physics and Mathematics) of the University and the Department of Manual Training of the University High School, the equivalent of three years of a four years' course in Chemical Engineering. Students are able to take a large part of this work in the purely scientific fundamental branches while candidates for a Bachelor's degree.

Recommendation of Students to Positions.—The Department of Chemistry does not undertake to secure positions for those who have studied in it, but as a matter of fact, worthy students find suitable places quickly, and in the past the demand for chemists of all the kinds mentioned above has far exceeded the supply.

SPECIAL STUDENTS.

Special or unclassified students, not candidates for a degree, will be received, and will be given every possible facility, but in every case they will be required to give evidence, satisfactory to the instructors in the different branches, that their previous training has been sufficient, both in latitude and amount, to enable them to derive full profit from the courses they propose to take.

FELLOWSHIPS AND SCHOLARSHIPS.

University Fellowships yielding an income of $320 or $520 annually are open to graduate students in chemistry. A Fellowship in Chemistry has been endowed since 1901 by Mr. Berthold Lowenthal, of Chicago, as a memorial of his son Joseph B. Loewenthal; it yields an annual income of $420. The appointments to these Fellowships will be based exclusively on merit. A Fellow will be expected to render assistance to the department by serving as an assistant at lectures or in the laboratory. In no case, however, will he be required, or allowed, to devote more than one-sixth of his time to such service.

One Senior College and one Graduate Scholarship are awarded yearly in accordance with the general regulations of the University, to two students graduating from the Junior and Senior Colleges respectively.

THE LIBRARY.

The Departmental Library is equipped with an almost complete list of periodicals, past and current, necessary for prosecuting research; it also possesses a large number of reference and handbooks.

A number of general scientific journals and many of the proceedings of learned societies are received in the General Library.

COURSES OF INSTRUCTION.

Summer Quarter, 1903 — Spring Quarter, 1904.

M=Minor course=a single course for six weeks. DM=Double Minor course=a double course (two hours daily) for six weeks. Mj=Major course=a single course for twelve weeks. DMj=Double Major course=double course for twelve weeks. Two hours of laboratory work are reckoned as equal to one hour of class-room work.

Primarily for the Junior Colleges.

1. **Elementary General Chemistry.**
Class-room, 3 hrs. a week, 12:00.
Laboratory, 6 hrs. a week.
Mj. Autumn Quarter.
Associate Professor Smith.

Prerequisite : *Preparatory Physics.*

2. **General Inorganic Chemistry I.**—Continuation of Course 1 or of Preparatory Chemistry.
Class-room, 3 hrs. a week, 8:30.
Laboratory, 6 hrs. a week.
Mj. Autumn Quarter.
Assistant Professor McCoy.
and Dr. Holmes.
Hours as in Course 1. Mj. Winter Quarter.
Associate Professor Smith.

3. **General Inorganic Chemistry II.**—Continuation of Course 2.
Class-room, 3 hrs. a week, 8:30.
Laboratory, 6 hrs. a week.
Mj. Winter Quarter.
Assistant Professor McCoy.
and Dr. Holmes.
Hours as in Course 1.
Mj. Spring Quarter.
Associate Professor Smith.

1, 2, 3 are consecutive courses. Separate credit is given for each. But students are not advised to take one course only. Students offering preparatory chemistry for admission take Course 2. Whenever the preparation justifies it, qualitative analysis may be substituted for 3.

The aim of the continuous Courses 1, 2, 3 will be to give a definite idea of the fundamental principles of chemistry, and not to overburden the student with a mass of unconnected facts. The conception of chemical equilibrium and the modern theory of solutions are freely used. The lectures will be experimental to a considerable extent. The courses are designed to meet the wants not only of those who wish to go deeper into chemistry, but of all who wish to secure a liberal education.

The lectures and class-room work of 1, 2, and 3 may be taken by graduate students without the laboratory work or laboratory fee.

1A. **General Inorganic Chemistry.**—*Elementary Course.* DM. First Term, Summer Quarter.
Class-room, 6 hrs. a week ; 11:00.
Laboratory work, 12 hrs. a week ; 2:00–5:00.
Associate Professor Smith.

Prerequisite : *Preparatory Physics.*

2A. **General Inorganic Chemistry.** — Continuation of Course 1A. Hours as in 1A.
DM. Second Term, Summer Quarter.
Assistant Professor McCoy.

The lectures and class-room work of 1A and 2A may be taken by Graduate Students without the laboratory work or laboratory fee.

1B. **General Inorganic Chemistry.**—*Special Course.*
DM. First Term, Summer Quarter.
Lectures, 6 hrs. a week ; 11:00.
Laboratory work, 12 hrs. a week ; 2:00–5:00.
Associate Professor Smith
and Professor Byers.

Students attend the same lectures as in Course 1A, but the laboratory work and recitations in Course 1B are independent and advanced.

Prerequisite : *Admission Chemistry* and *Physics, 1 unit each.*

2B. **General Inorganic Chemistry.**—*Special Course.* Continuation of Course 1B. Hours as in 1B.
DM. Second Term, Summer Quarter.
Assistant Professor McCoy
and Professor Byers.

For description see under 3.

4. **Elementary Organic Chemistry.**
Class-room 3 hrs. a week; 8:30.
Laboratory work, 6 hrs. a week.
Mj. Autumn Quarter.
Dr. Jones.

Prerequisite : *Course 3, or 2A, or 2B, General Chemistry.*

Primarily for the Senior Colleges.

Note.—Courses 6, 7, 8, 9, 10, 11, and 13 are given in the analytical laboratories. The laboratories are open from 8:00 a.m to 6:00 p.m. (Saturdays only to 1:00 p.m.) The hours of instruction provide for morning and afternoon sections and will be posted in the laboratory.

Courses 6, 7, 8, and 9 will count toward a Master's or the Doctor's degree when Chemistry is the *secondary* subject.

6. **Qualitative Analysis.**—*Introductory Course.* Mj or DM. 8 or 16 hrs. a week laboratory. 2 hrs. a week class-room. Lectures, 2:00.
Summer, Winter and Spring Quarters.
Dr. Jones.
Autumn Quarter.
Associate Professor Stieglitz and Dr. Holmes.
Prerequisite: *Course 3*, or *2A*, or *2B*.

The lectures deal with the chemistry of the analytical reactions, and special attention is given to the development and application of the laws of equilibrium and solutions. This course is, in an important sense, one in advanced general chemistry.

7. **Qualitative Analysis.**—Continuation of Course 6. Hours as in 6.
Mj or DM. Summer, Winter and Spring Quarters.
Dr. Jones.
Autumn Quarter.
Dr. Holmes.

Courses 6, 7, 10 form a continuous course, which may be begun in the Summer, Autumn, or Spring Quarters.

The aim of Courses 6, 7, 10 will be to train the student to do intelligent analytical work based on a knowledge of the scientific principles of the subject and to apply and amplify his knowledge of general and physical chemistry.

8. **Quantitative Analysis.**—*Introductory Course.*—Chiefly laboratory work in gravimetric and volumetric analysis.
Mj or DM. 8 or 16 hrs. a week, laboratory. Lecture, 1 hour. Summer Quarter.
Dr. Jones and Mr. Derby.
Autumn, Winter, and Spring Quarters.
Associate Professor Stieglitz and Mr. Derby.
Prerequisite: *Qualitative Analysis* (Courses 6 and 7).

9. **Quantitative Analysis.**—Continuation of Course 8, Mj or DM. 10 or 20 hrs. a week, laboratory.
Summer Quarter.
Dr. Jones.
Autumn, Winter, and Spring Quarters.
Associate Professor Stieglitz.

Courses 8, 9, 11 form a continuous course, which may be begun in any Quarter.

Primarily for the Graduate School.

10. **Advanced Qualitative Analysis.**—Mj or DM. 10 or 20 hrs. a week, laboratory.
Summer, Winter, and Spring Quarters.
Dr. Jones.
Autumn Quarter.
Dr. Holmes.

Open to College students. Continuation of Courses 6 and 7.

11. **Advanced Quantitative Analysis.**—Mj or DM. 10 or 20 hrs. a week. Summer Quarter.
Dr. Jones.
Autumn and Winter Quarters.
Associate Professor Stieglitz.

Continuation of Courses 8 and 9. Open to students in the Senior Colleges.

12. **Elementary Spectrum Analysis (Qualitative).**—Emission (flame and electric spark) and absorption spectra of inorganic substances. Chiefly laboratory work. ½Mj. Winter Quarter.
Dr. Jones.

13. **Special Methods in Quantitative Analysis.**—Chiefly laboratory work.

13A. Electrolytic Methods.	½Mj or Mj.
13B. Special Mineral Analysis.	Mj.
13C. Water Analysis.	½Mj.
13D. Gas Analysis.	½Mj.
13E. Organic Elementary Analysis.	½Mj.

Summer Quarter.
Dr. Jones.
Autumn, Winter, and Spring Quarters.
Associate Professor Stieglitz.
Prerequisite: *Quantitative Analysis.*

13F. **Assaying.**—Fire-assay of gold, silver, and lead ores. Mj. Spring Quarter.
Mr. ———.

Prerequisite: *General Chemistry, Qualitative and Quantitative Analysis* (Courses 8 and 9).

13G. **Iron and Steel Analysis.** Mj. Winter Quarter.
Associate Professor Stieglitz.
Prerequisite: *Courses 8 and 9.*

14. **Organic Chemistry.**—Lectures, 3 hrs. a week.
Mj. Autumn Quarter; 12:00.
Professor Nef.

Prerequisite: *General Chemistry and Qualitative Analysis.*

15. **Organic Chemistry.** — Continuation of Course 14.
Mj. Winter Quarter; 12:00.
PROFESSOR NEF.

16. **Organic Chemistry.**—Continuation of Course 15.
M. First Term, Spring Quarter; 12:00.
PROFESSOR NEF.

Courses 14, 15, 16 form a continuous course, covering the compounds of carbon, including the fatty and the aromatic series. The aim of the course will be to take up very thoroughly the simpler compounds, going with great detail into the chemical behavior, the characteristic reactions and relationships of the different classes of organic compounds, and considering with great care the synthetic methods by which they can be obtained. Richter's or Bernthsen's *Organic Chemistry* is used as a reference book, but recent literature will, in special cases, be considered in detail.

17. **General Organic Chemistry.**—Fatty and aromatic series.
Lectures, 5 hrs. a week.
Mj (or M. First Term). Summer Quarter ; 8:30.
DR. HESSLER.

Prerequisite : *General Chemistry and Qualitative Analysis.*

18. **Elementary Organic Preparations.**—Laboratory work ; 10 hrs. a week. This course is arranged to accompany the lectures of Course 17. It may be taken without the lectures by students who have had organic chemistry.
½Mj or Mj. Summer Quarter.
DR. HESSLER.
Prerequisite : *As in Course 17.*

19. **Toxicology.** ½Mj. Autumn Quarter.
PROFESSOR HAINES AND ASSISTANT.

19B. **Poisons and Their Detection.**—A conference and laboratory course.
M. Second Term, Spring Quarter.
PROFESSOR HAINES.

20. **Organic Preparations.**—Laboratory work, 10 or 20 hrs. a week.
Mj or DM. Autumn, Winter, and Spring Quarters.
PROFESSOR NEF.
Summer Quarter.
DR. HESSLER.

Prerequisite: *Qualitative and Quantitative Analysis*, and *Organic Chemistry* (it may be taken simultaneously in connection with lectures on Organic Chemistry). A reading knowledge of German is essential.

21. **Organic Preparations.**—Continuation of Course 20.
Mj or DM. Autumn, Winter, and Spring Quarters.
PROFESSOR NEF.
Summer Quarter.
DR. HESSLER.

22. **Organic Preparations.**—Continuation of Course 21.
Mj or DM. Autumn, Winter, and Spring Quarters.
PROFESSOR NEF.
Summer Quarter.
DR. HESSLER.

23. **Physical Chemistry Applied to Problems in General Chemistry.** 2 hrs. a week. ½Mj.
ASSOCIATE PROFESSOR SMITH.

Prerequisite: *College Physics*, *General Chemistry, and Qualitative Analysis.*
[Not to be given in 1903-4.]

24. **Advanced Inorganic Chemistry.**—Two lectures a week on selected topics.
½Mj. Spring Quarter.
DR. JONES.
Prerequisite : *General Chemistry and Qualitative Analysis.*

25. **Inorganic Preparations.**—Laboratory work.
Mj or DM. 10 or 20 hours a week.
First Term, Summer Quarter.
ASSISTANT PROFESSOR MCCOY.
Autumn and Winter Quarters.
DR. JONES.
Prerequisite : *Qualitative and Quantitative Analysis, and a reading knowledge of German.*

26. **Inorganic Preparations.**—Continuation of Course 25. Mj or DM. First Term, Summer Quarter.
ASSISTANT PROFESSOR MCCOY.
Autumn and Winter Quarters.
DR. JONES.

27. **Inorganic Preparations.**—Continuation of Course. 26. Mj or DM. First Term, Summer Quarter.
ASSISTANT PROFESSOR MCCOY.
Autumn and Winter Quarters.
DR. JONES.

28A. **Elementary Physical Chemistry.**—With special reference to Physico-Chemical measurements.
M. First Term, Summer Quarter.
ASSISTANT PROFESSOR MCCOY.
½Mj. 2 hrs. a week. Spring Quarter.
ASSOCIATE PROFESSOR SMITH.

Prerequisite: *College Physics* (Course 1) *and Qualitative Analysis* (Course 6).

28B. **Practical Physical Chemistry.**

M. First Term, Summer Quarter.
ASSISTANT PROFESSOR McCOY.
½Mj or Mj. 5 to 10 hrs. a week.
Spring Quarter.
ASSOCIATE PROFESSOR STIEGLITZ.

Prerequisite: *College Physics* (Course 1), *Quantitative Analysis* (Course 8); Course 28A should accompany or precede this course.

29. **Chemical Dynamics.** ½Mj. 2 hrs. a week.
Autumn Quarter; 12:00.
ASSISTANT PROFESSOR McCOY.

Prerequisite: *Elementary Physical and Organic Chemistry, including laboratory work; the elements of calculus.*

30. **Electro Chemistry.**
½Mj. 2 hrs. a week. Winter Quarter.
ASSISTANT PROFESSOR McCOY.

Prerequisite: *Elementary Physical Chemistry, including laboratory work*; *the elements of calculus.*

31. **Advanced Physical Chemistry.** — Laboratory course.
Mj or DM. Autumn and Winter Quarters.
ASSISTANT PROFESSOR McCOY.

Prerequisite: *College Physics, 1 year.* Course 29 should accompany or precede this course.

32. **Advanced Physical Chemistry.** — Laboratory course. Continuation of Course 31.
Mj or DM. Autumn and Winter Quarters.
ASSISTANT PROFESSOR McCOY.

33. **Research Work.**—This course will include from 30 to 40 hrs. a week of laboratory work, under the special direction of some one of the instructors in the department. It is expected that research work for a Ph.D. thesis will require 4–6 quarters, 4–6 DMj.

33*a*. RESEARCH IN ORGANIC CHEMISTRY. — Autumn, Winter, and Spring Quarters.
PROFESSOR NEF.

33*b*. RESEARCH IN GENERAL CHEMISTRY.—Summer, First Term, Autumn, Winter, and Spring Quarters. ASSOCIATE PROFESSOR SMITH.

33*c*. RESEARCH IN ORGANIC AND PHYSICO-ORGANIC CHEMISTRY.—Autumn, Winter, and Spring Quarters. ASSOCIATE PROFESSOR STIEGLITZ.

33*d*. RESEARCH IN PHYSICAL CHEMISTRY.—Summer, Autumn, and Winter Quarters.
ASSISTANT PROFESSOR McCOY.

Before being admitted to Research, a candidate must satisfy the instructors of the department, by an oral test, or otherwise, that his previous training has been sufficient.

34. **Physical Chemistry Applied to Organic Problems.** Lectures, 2 hrs. a week.
½Mj. Winter Quarter.
ASSOCIATE PROFESSOR STIEGLITZ.

Prerequisite: *Organic Chemistry and Elementary Physical Chemistry.*

35. **The Carbohydrates and the Terpenes** (and their derivatives).— Lectures, 2 hrs. a week.
½Mj. Autumn Quarter; 8:30.
ASSOCIATE PROFESSOR STIEGLITZ.

Prerequisite: *Organic Chemistry.*

[Not to be given in 1903–4.]

36. **Organic Nitrogen Derivatives.**—Uric acid series; pyridine, quinone-imides, and phenazine compounds; a discussion of the alkaloids, ptomaines, and organic dye-stuffs.
Lectures, 2 hrs. a week.
½Mj. Winter Quarter; 8:30.
ASSOCIATE PROFESSOR STIEGLITZ.
Prerequisite: *Organic Chemistry.*

[Not to be given in 1903–4.]

37. **Special Chapters of Organic Chemistry.**— Lectures, 4 hrs. a week.
M. Second Term, Spring Quarter; 12:00.
PROFESSOR NEF.

Prerequisite: *Organic Chemistry.*

38. **The Aromatic Series.**—Lectures, 2 hrs. a week.
½Mj. Autumn Quarter.
DR. HESSLER.

Prerequisite: *Organic Chemistry.*

40. **The Teaching of Chemistry.**— A series of Conferences and Lectures on the Didactic of Chemistry.

½Mj. Summer Quarter. First Term, and Spring Quarter; Wed., 2:00–4:00.

ASSOCIATE PROFESSOR SMITH.

42. **History of Chemistry.** — 2 hrs. a week. Winter and Spring Quarters. Two ½Mj.

[Not to be given in 1903–4.]

43. **Club Meetings.**

Summer, Autumn, Winter, and Spring Quarters.

VARIOUS MEMBERS OF THE STAFF.

Meetings will be held twice a month. They may be attended by anyone interested, whether connected with the University or not; the subjects for the meetings will be announced at least one week beforehand.

THE KENT CHEMICAL LABORATORY.

OFFICERS OF GOVERNMENT.

JOHN ULRIC NEF, *Professor and Head of the Department of Chemistry.*
ALEXANDER SMITH, *Associate Professor of General Chemistry.*
JULIUS STIEGLITZ, *Associate Professor of Chemistry.*
HERBERT NEWBY McCOY, *Assistant Professor of Chemistry.*
JOHN C. HESSLER, *Instructor in Chemistry.*
LAUDER W. JONES, *Instructor in Analytical Chemistry.*
WILLIS B. HOLMES, *Associate in Chemistry.*
IRA HARRIS DERBY, *Assistant in Quantitative Analysis.*
ROY HUTCHISON BROWNLEE, *Lecture Assistant in Chemistry.*
RICHARD BLAIR EARLE, *Research Assistant in Chemistry.*
WALTER FULLER, *Laboratory Inspector.*

WALTER STANLEY HAINES, *Professor of Chemistry, Pharmacy, and Toxicology, Rush Medical College; Professorial Lecturer on Toxicology.*

THE BUILDING.

The Chemical Laboratory, provided by the generosity of Mr. Sidney A. Kent, was opened January 1, 1894.

The rooms are arranged as follows:

The *basement* contains a furnace room, with a set of gas furnaces, with air blast of the most modern construction, for crucible work, muffle work, tube heating, and other purposes; a constant temperature room, a room fitted with steam and other appliances for work on a large scale, a mechanical workshop, and storage rooms.

On the *first floor* are one small and two large lecture rooms, and a large lecture hall seating three hundred persons, fitted for use as a chemical lecture room, if desired. This floor also contains a chemical museum, a large private laboratory, a room with northern exposure, especially fitted for use as a gas analysis laboratory, and also apparatus and preparation rooms connected with the lecture rooms.

On the *second floor* are two large laboratories intended for research and quantitative analysis, three private laboratories for the professors, balance, combustion, air furnace, and storerooms, a balcony for out-of-door work, and the chemical library, which contains full sets of the most important journals, as well as the most important text-books and other works, relating to chemistry.

On the *third floor* are three large laboratories for general and analytical chemistry, a storeroom, a preparation room, a room especially fitted for optical and photographic work, a balance room, and two private laboratories. The most modern system of ventilation has been adopted, air of constant temperature being forced in by fans from below, and withdrawn by a fan above. The building will be lighted throughout by electric lights, and the laboratories will be provided with electricity adapted to every kind of electro-chemical work.

The fullest opportunity will be given for doing research work. All possible aid will be afforded those who desire to avail themselves of the facilities of the laboratory.

UNIVERSITY OF ILLINOIS-URBANA
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